

2nd Grade – Engineering & Design

Objective:

Students will learn about the engineering of flight and the design of gliders by making their own rocket and glider.



ETS1.A: Defining and Delimiting Engineering Problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
 - The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)
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Docent Lab Guidelines:

1. Docent(s) should plan to arrive early to set up before the class arrives.
2. Reserve the science room on the Science Lab Master Schedule. Please make sure you add 30 minutes of set up time and about 30 minutes of clean up time to the overall class time. This lab should not be too messy.
3. Safety glasses are to be worn while rockets and gliders are launched. But aprons/lab coats are not required.
4. Give a 5-10 minute overview of how planes and gliders fly as well as discussing gravity. You can also opt to play a short video instead of speaking. These are listed below.

5. There are how-to videos showing step-by-step instructions for making the glider and rockets. Docents should watch these before class to understand the steps so they can give students direction during class.
 6. Docents may want to have two tables set up with materials for the rocket and two table with materials for the glider with docents stationed at each table to provide help when needed. Students can move between the two tables so they get a chance to make both rocket and glider if they would like.
 7. Allow enough time at the end for students to wash up afterwards, if needed.
 8. The last 5-10 minutes of class review the student's observation as a group.
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(For Docent's Reference Only)

This session involves engineering; specifically the science and design of flight. Discuss with the class what makes a glider fly and how the design of the glider might affect its performance in the air. Students will have a chance to make a slingshot glider and rocket. Give them some guidance on how to make it but let them try creating their own design and testing it out. Some may make long thin wings others short and wide wings. Also the position of the wings plays an important part in how it flies. Encourage students to test out their design (as a scientist would) and then come back and make adjustments. At the end of class wrap up the session with an overview of what they learned. Which rockets/gliders went the furthest? Why? What were some design problems encountered? How were these challenges solved?

Below are two How-do videos for the docents to watch before class. These are step-by-step instructions on how to make the slingshot rocket and glider.

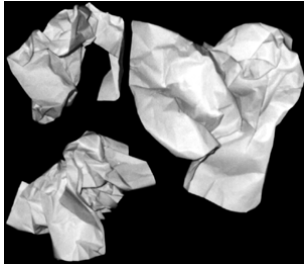
- Slingshot glider how-to
<http://www.instructables.com/id/Teach-Engineering-Slingshot-Rockets/>
- Slingshot rocket how-to video
<https://www.youtube.com/watch?v=UmOc-w2oUD4>

Information on Gliders by *Newton's Apple*:

Sailplanes are probably the closest thing any human will come to feeling like a bird. Powered only by gravity and air currents, gliders move silently through the air. Sailplanes stay in the air by balancing the forces of gravity, drag and thrust.



As you might suspect, if you want to stay airborne for a long time, the most important force to conquer is gravity. Lift, the force that directly opposes gravity, comes from the force of the air on the underside of the wing. In wings, lift is controlled by three factors: surface area, shape, and [angle of attack](#).



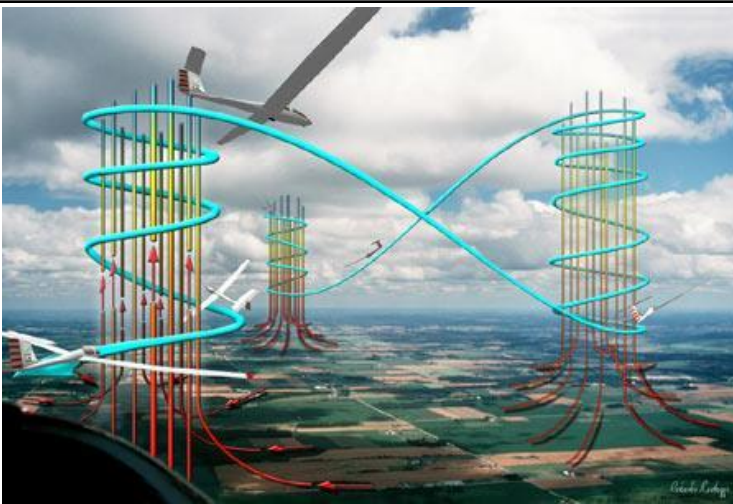
To see how surface area works, roll a piece of paper into a ball. Drop it and the paper falls. Spread the paper out and drop it, and it will float. The greater the surface area, the greater the amount of air pushing up on the wing.

The shape of the wing works because of something called [Bernoulli's principle](#). Most wings are curved on the top and flat on the bottom. As the wing pushes through the air, the air on top of the wing must move a little faster than the air on the bottom. This creates slightly lower pressure on the top, which allows the greater air pressure beneath the wing to push the plane up.

The [angle of attack](#) is the orientation of the wing as it faces into the wind. Increasing the angle of attack means increasing the amount of air hitting directly on the bottom, which gives the wing more lift. Of course, if you make the angle of attack too big, the wing will blow backwards, and the plane will come crashing down!



In a sense, a sailplane is very similar to a roller coaster. Both are towed up high and released. They begin to fall and the force of gravity gets them going. Unlike a roller coaster, which continuously loses height, a sailplane can also gain elevation by riding rising currents of air. Known as thermals, these localized updrafts are caused by air being heated by the warm ground below.



When the sun shines down on a sandy beach, for example, the sand heats up faster than the water. As the air in contact with the sand begins to heat up, it expands and rises. This differential heating is what causes thermals and when a glider hits one, it can fly for hours at a time.

Videos on Flight:

1. The Wright Brother's First Flight, 1903 – A Day that Shocked the World - (Run (time 3 min. 8 sec. – **Skip the first 24 seconds of the video**)
<http://www.watchknowlearn.org/Video.aspx?VideoID=36603&CategoryID=14581>
2. Flight – a video for kids (run time 2 mins. 30 secs.)
<http://ca.pbslearningmedia.org/resource/idptv11.sci.phys.maf.d4kfli/flight/>

Experiment #1: Slingshot Rocket

Materials:

- Straws
- Rubber bands
- Paperclips
- Masking tape
- Cardstock
- Craft sticks
- Markers
- Scissors
- Stopwatch (optional)

Preparation:

1. Bend the paperclips, as shown in the video, before the class starts or the day before. Make more than needed for the class in case some students make more than one rocket or they get lost.
2. Pre-cut masking tape.
3. Docents may want to pre-cut the triangles. Alternatively you can make a template for the students to trace and then cut their own cardstock.
4. At tables set out all cardstock, straws, rubber bands, masking tape, scissors and markers.
5. Docents may consider making a sample rocket or building a rocket at the same time as the students. This way students can follow along and watch each step.

How-to video – watch before class:

<https://www.youtube.com/watch?v=UmOc-w2oUD4>

Instructions:

1. Start by cutting out two rectangles the same size. Then cut the rectangle into triangles by cutting from one corner to the opposite corner. You will end up with 4 triangles all the same size.
2. These 4 triangles become rocket fins. Students can decorate their fins with markers.
3. Take a piece of masking tape about the length of the fin and place the tape along the long edge of the fin so half of it is on the fin and half is exposed.

4. Tape the fin to one end of the straw leaving about $\frac{1}{2}$ inch of the straw exposed at the bottom.
5. Put the straw down and grab another piece of tape.
6. Put another strip of masking tape on another fin and tape it to the straw next to the first one. Continue with all four fins. The fins will form an "X".
7. Make sure the fins are straight and symmetric.
8. Take 1 bent paperclip and attach it to straw on the end opposite the fins. Attach with masking tape. Make sure to wrap the tape all the way around the straw so it is securely fastened.
9. Next take two strips of tape about 3-4 inches long and tape them together.
10. Place 1 rubber band in the center of the tape.
11. Grab a craft stick and with the rubber band on at the top of the craft stick and touching the craft stick, fold the tape over the craft stick. The tape will be folded in half over the craft stick. This is the launcher.
12. To launch the rocket – hook the bend edge of the paperclip onto the rubber band launcher. Pull back the rocket holding it by the back end. Fling the launcher forward and release the rocket.
13. Students can test their rockets for distance and time. While they launch their rocket another student can use a stopwatch and test how long their rocket glides.
14. If the teacher is OK with it they can test their rockets outside as long as there is a docent with them.
15. Put their names on the rocket and take it home.

Experiment #2: Slingshot Glider

Estimated hands-on time: 10-15 minutes

Materials:

- Cardstock
- Rubber bands
- Straws
- Stapler
- Scotch tape
- Scissors
- Notched ruler or notched painting stick
- Stopwatches
- Markers

How to video – Watch before class:

https://www.youtube.com/watch?v=i_3p5Csyp4I

Preparation:

1. Before class arrives at each table set out supplies: cardstock, scissors, straws, tape and staplers.
2. Docents may consider making a sample or making one with the students. This way students can follow along and watch each step.

Instructions:

1. Begin by cutting out the wings. This can be one long rectangle. Roughly about 11 inches long. Students can play with different shaped wings to see how the design is affected. Students can decorate their wings using markers.
2. Find the middle of the wings. Place the straw in the middle of the wings. Use a rubber band to attach the wings. Attaching the wings with a rubber band allows for adjustments in the placement along the body of the glider. Loop the rubber band under the straw at one end over the top of the wings and over the opposite end of the straw, as shown in the video.
3. Next make the tail fins. Cut a smaller rectangle out of cardstock. Cut that rectangle in half so that you now have two equal size rectangles. Decorate the fins with markers if desired.
4. Cut a small slit in one end of the straw (this will become the back end of your glider).
5. Slide both rectangles into the slit in the straw one on top of the other, with no overlap.
6. Staple the tail fins to the straw lengthwise.
7. Gently bend the tail fins up.
8. Take another rubber band and insert it into the front of the glider (the front end of the straw) and staple it in place lengthwise.
9. Before launching the glider you will need to find the center of gravity. ([Discuss center of gravity with the students](#)). Find the center of gravity by balancing the glider on your index finger until it is perfectly balanced. You will need to adjust the location of the wings to find the center of gravity by sliding it up and down the body of the glider.
10. To launch the glider – hook the front end of the glider's rubber band onto the notched ruler. Pull back on the glider, aim, release.
11. Students can test their rockets for distance and time. While they launch their rocket another student can use a stopwatch and test how long their rocket glides. Once a student is satisfied with their design they can make modifications to their design and see if they end with better or worse results. Try bending the wings. Making smaller wings. Changing the angle of launch, etc.
12. If the teacher is OK with it they can test their rockets outside as long as there is a docent with them.
13. Put your name on your glider and take it home but please return the painting stick for other classes.

Questions

1. What were some of the common features of the planes with the longest flight times?
2. How did the size and shape of the wings affect the way the planes flew?
3. What other materials besides paper might you use in constructing your plane to get an even longer flight time?

Tips

1. If time is limited docents can pre-cut all the cardstock pieces for the glider and the rockets.