NASA Glenn Research Center Engineering Design Challenge

National Aeronautics and Space Administration


EDC-02: Let It Glide

www.nasa.gov

Welcome
NASA Engineer Trainees

Aerospace Engineer Chris Randall tests rocket parts and life support systems to ensure they work as planned.

Simulation System Engineer Debbie Martinez works on developing a general aviation flight simulation software.

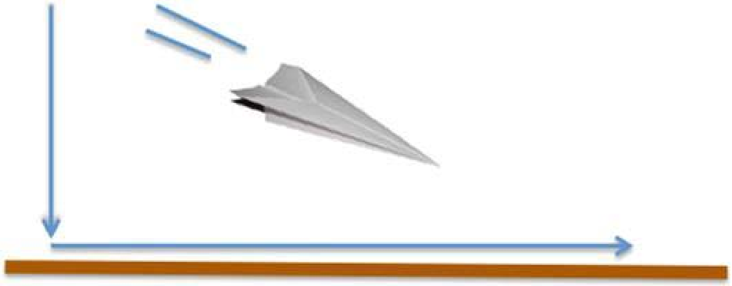
Introductory Video

https://www.youtube.com/watch?v=ium3IS41Xqc

Let It Glide

The Challenge:

- The glider must include an intact shoebox that simulates a space for a scientific payload to carry instruments for in-flight research.
- The glider must show improvement in glide slope with a positive percent change over the course of the challenge.
- The glider must not break apart in flight or upon landing.

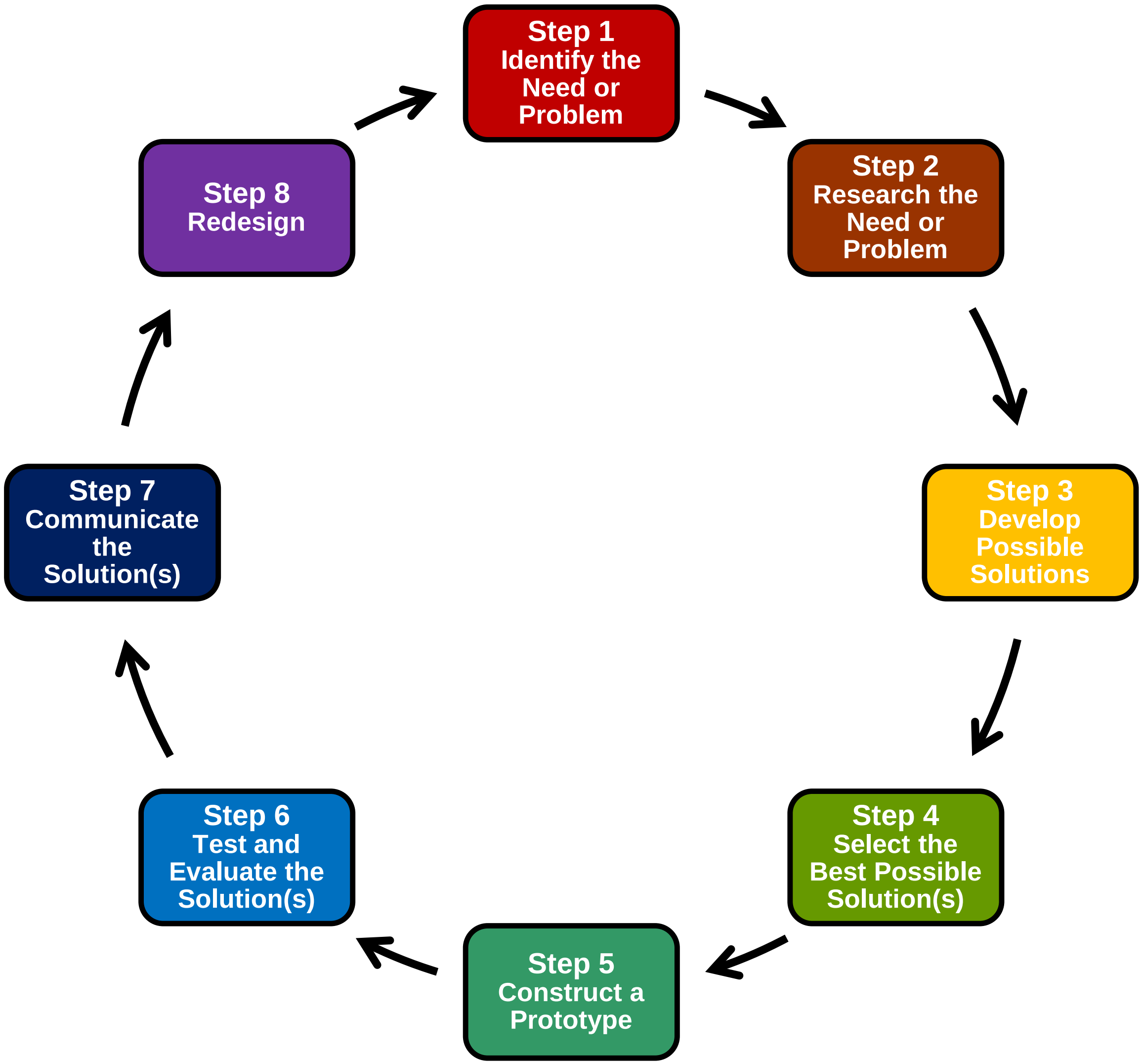


$$\frac{\textbf{horizontal distance traveled}}{\textbf{vertical distance traveled}} = \textbf{glide slope}$$

Let It Glide

- Students work in teams of four.
- Each team should choose a team name.
- One team member will act as lead in the following roles
  - Design engineer–sketches, outlines, patterns, or plans the ideas the team generates
  - Technical engineer–assembles, maintains, repairs, and modifies the structural components of the glider
  - Operations engineer–sets up and operates the glider to complete a test
  - Technical writer/Videographer–records and organizes information, data, and prepares documentation, via pictures and/or video to be reported and published

The Engineering Design Process

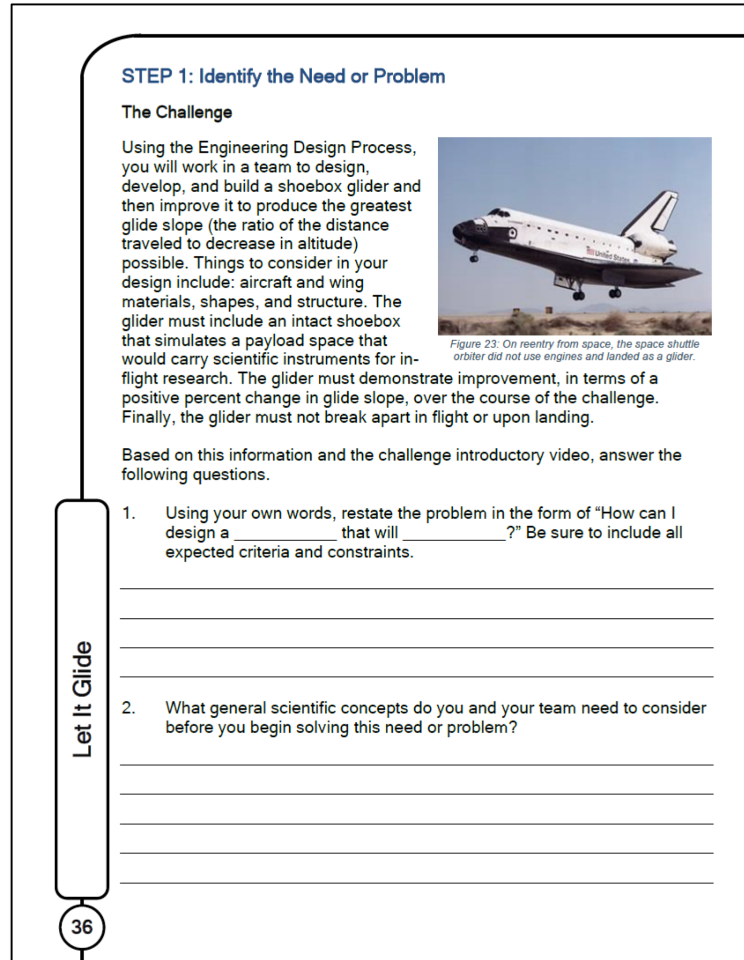


Step 1: Identify the Need or Problem

- State the problem in your own words.

  Example: "How can I design a ___________ that will __________?"

- Determine what general scientific concepts you will need to consider before beginning to solve the problem.



STEP 1: Identify the Need or Problem

The Challenge

Using the Engineering Design Process, you will work in a team to design, develop, and build a shoebox glider and then improve it to produce the greatest glide slope (the ratio of the distance traveled to decrease in altitude) possible. Things to consider in your design include: aircraft and wing materials, shapes, and structure. The glider must include an intact shoebox that simulates a payload space that would carry scientific instruments for in-flight research. The glider must demonstrate improvement, in terms of a positive percent change in glide slope, over the course of the challenge. Finally, the glider must not break apart in flight or upon landing.

Figure 23: On reentry from space, the space shuttle orbiter did not use engines and landed as a glider.

Based on this information and the challenge introductory video, answer the following questions.

1. Using your own words, restate the problem in the form of "How can I design a ___________ that will ___________?" Be sure to include all expected criteria and constraints.

2. What general scientific concepts do you and your team need to consider before you begin solving this need or problem?

Let It Glide

Step 2: Research the Need or Problem

Examine how this problem is currently being solved or how similar problems are being solved.

STEP 2: Research the Need or Problem

Conduct research to answer the following questions related to the challenge. Cite where you found your information on the lines labeled "Source(s)".

1. Who is currently working on this or a similar problem today? What solutions have they created or are working on currently?

Source(s):

2. What questions would you ask an expert who is currently trying to solve problems like this one?

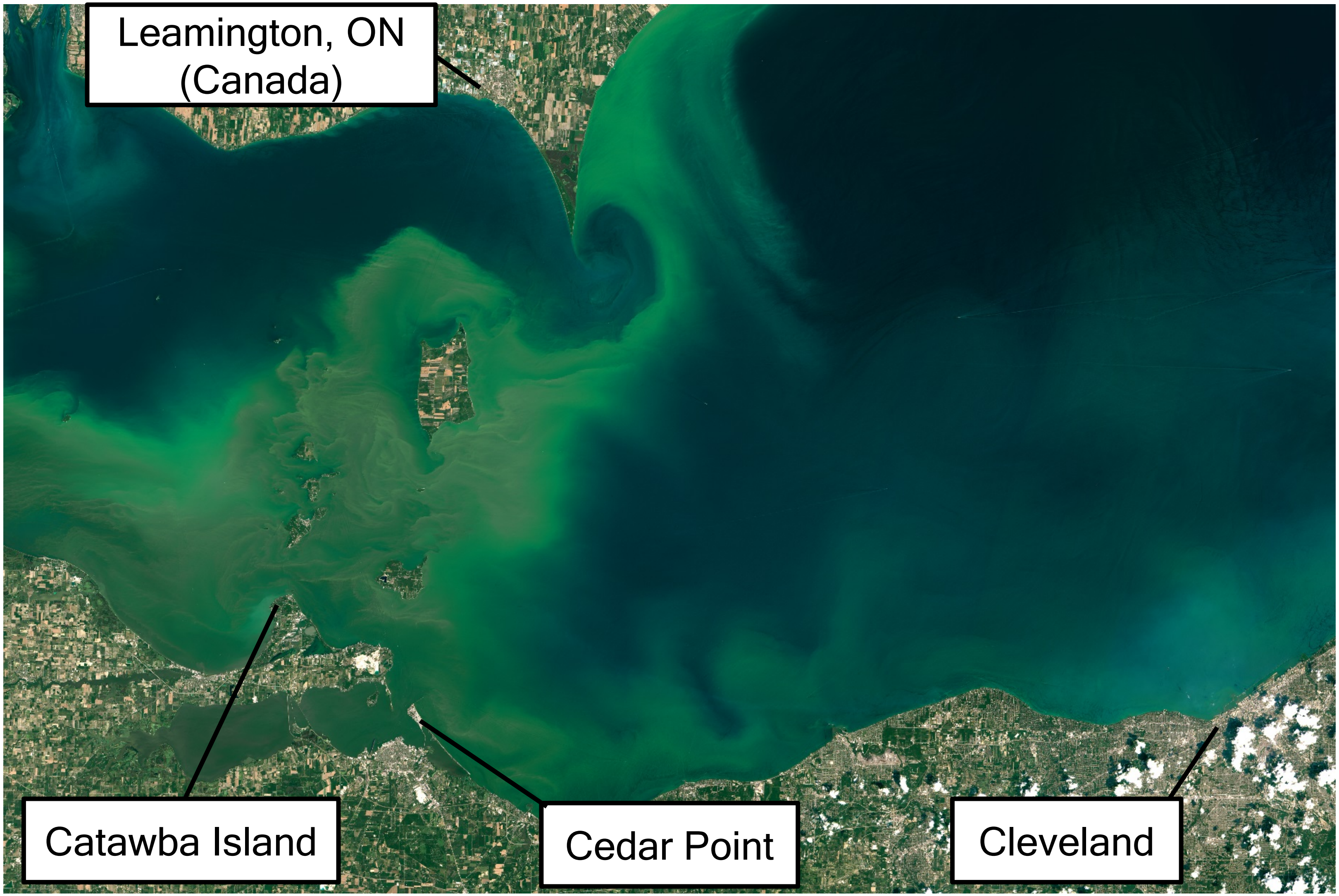
3. Who in our society will benefit from this problem being solved? How could this relate to everyday use?

Source(s):

4. What are some innovative options for using the materials that are available to solve this challenge?

Source(s):

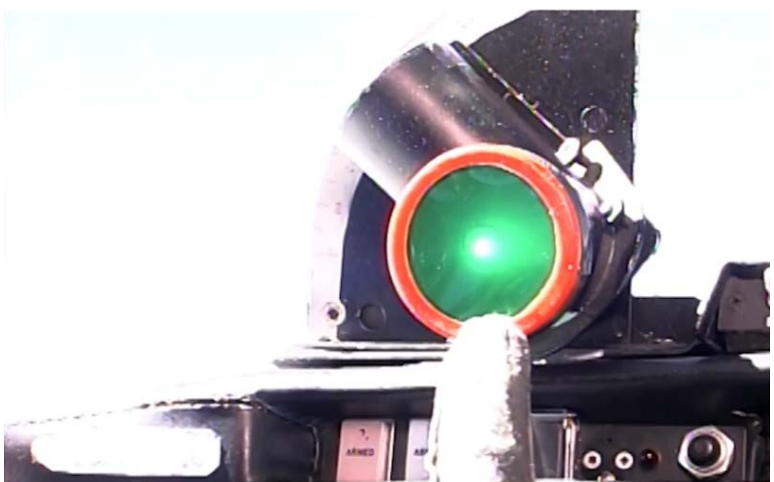
Step 2: Research the Need or Problem



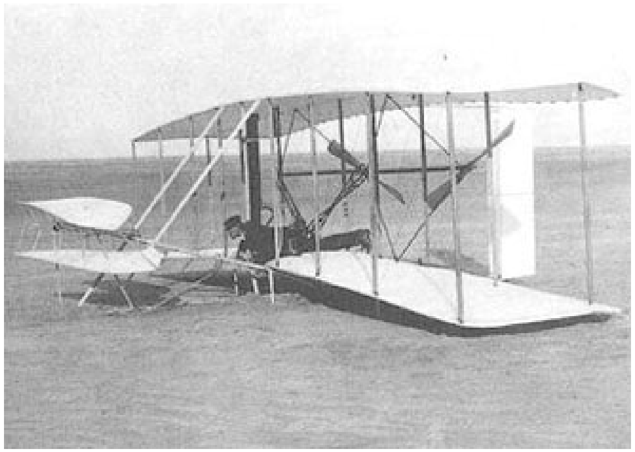
Step 2: Research the Need or Problem

What is similar about these planes? What is different?

Step 2: Research the Need or Problem



Other Types of Aircraft: Historic Aircraft



Wright Brothers

Biplane

Amphibious

Twin-engine

Delta-wing

Other Types of Aircraft: Unique Aircraft

Blended-wing-body

Military

Unmanned aerial systems (Drones)

High-altitude

Solar-powered

Other Types of Aircraft: Gliders

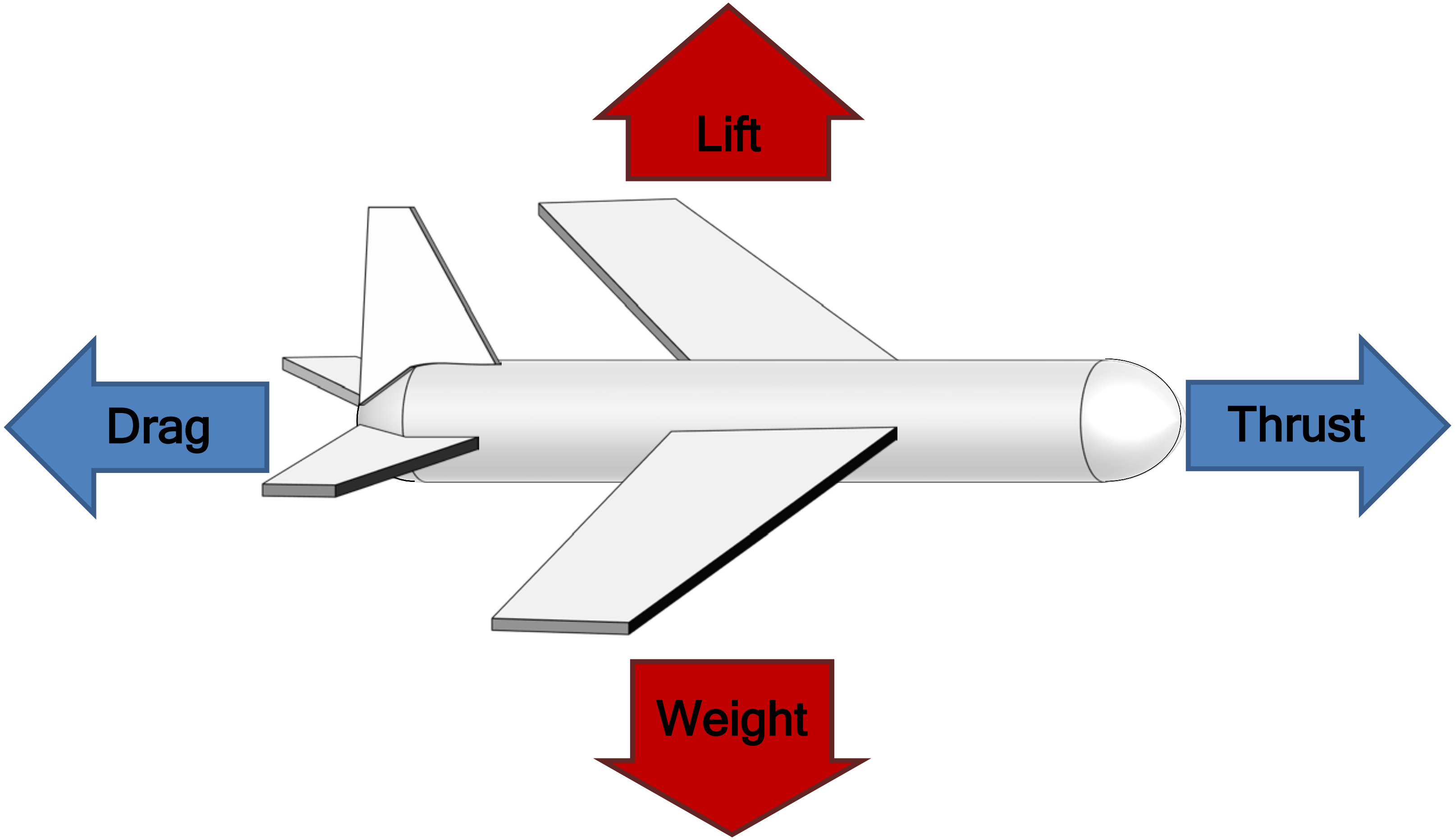
Hang glider

Sailplane

Toy glider

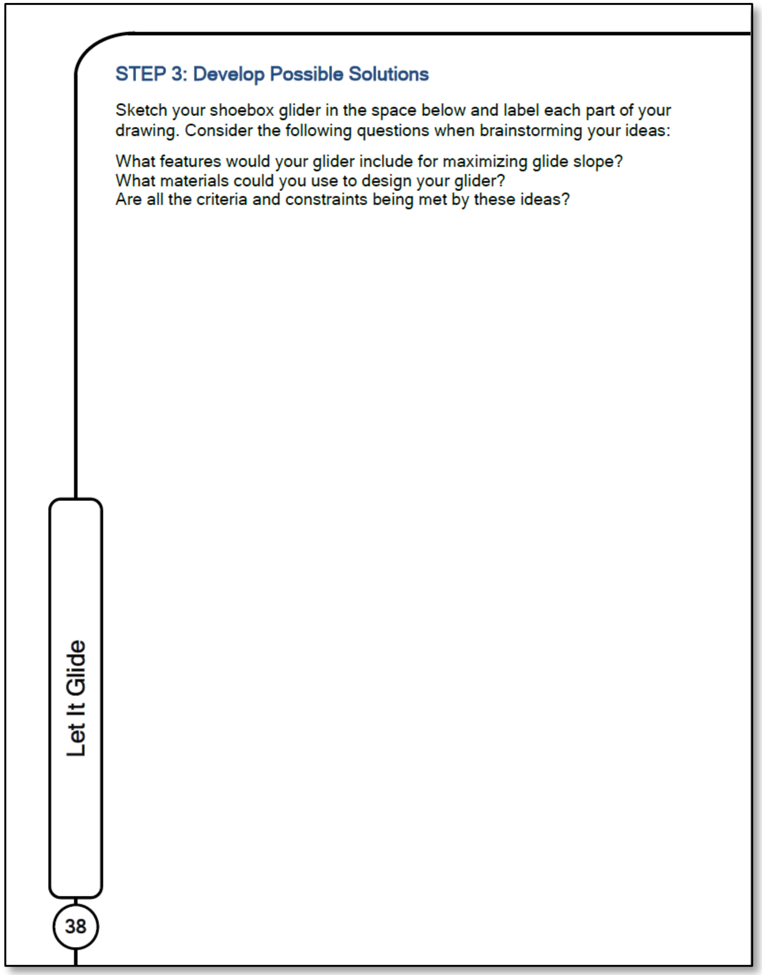
Space shuttle

The Four Forces of Flight



Step 3: Develop Possible Solutions

- Use your mathematic and scientific knowledge to brainstorm all the possible ways you can think of to create a glider.
- Quickly sketch your design, using labels and arrows to identify parts.



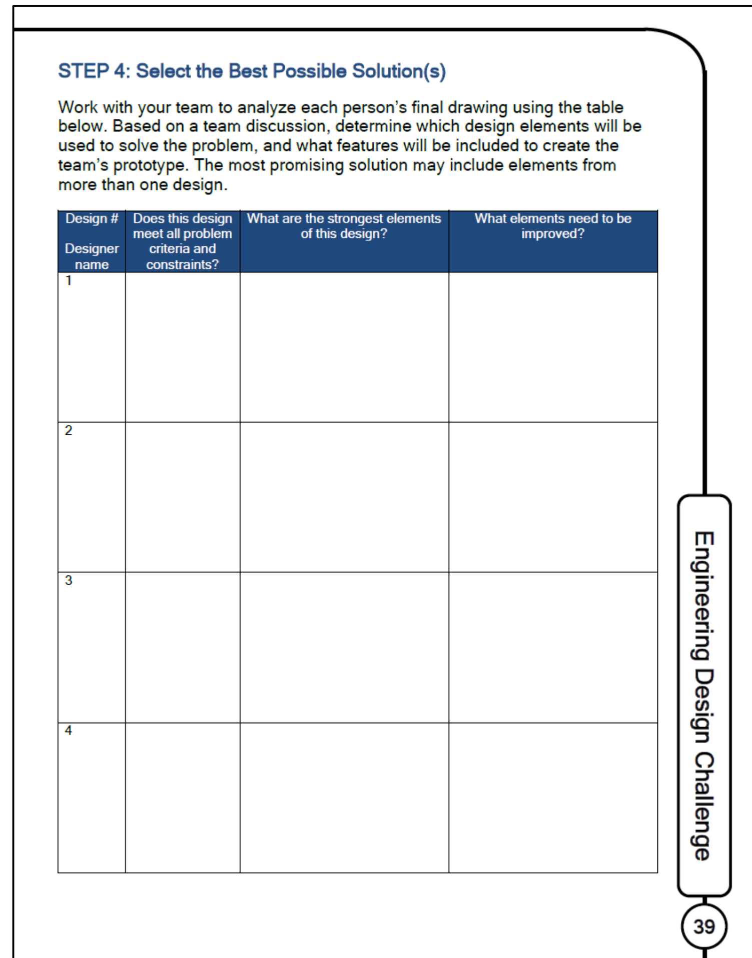
STEP 3: Develop Possible Solutions

Sketch your shoebox glider in the space below and label each part of your drawing. Consider the following questions when brainstorming your ideas:

What features would your glider include for maximizing glide slope?
What materials could you use to design your glider?
Are all the criteria and constraints being met by these ideas?

Step 4: Select the Best Possible Solution(s)

- Share your ideas with your team.
- Discuss strengths and weaknesses from each design
- Which design best solves the challenge? Are there parts from other designs that could improve that idea?



STEP 4: Select the Best Possible Solution(s)

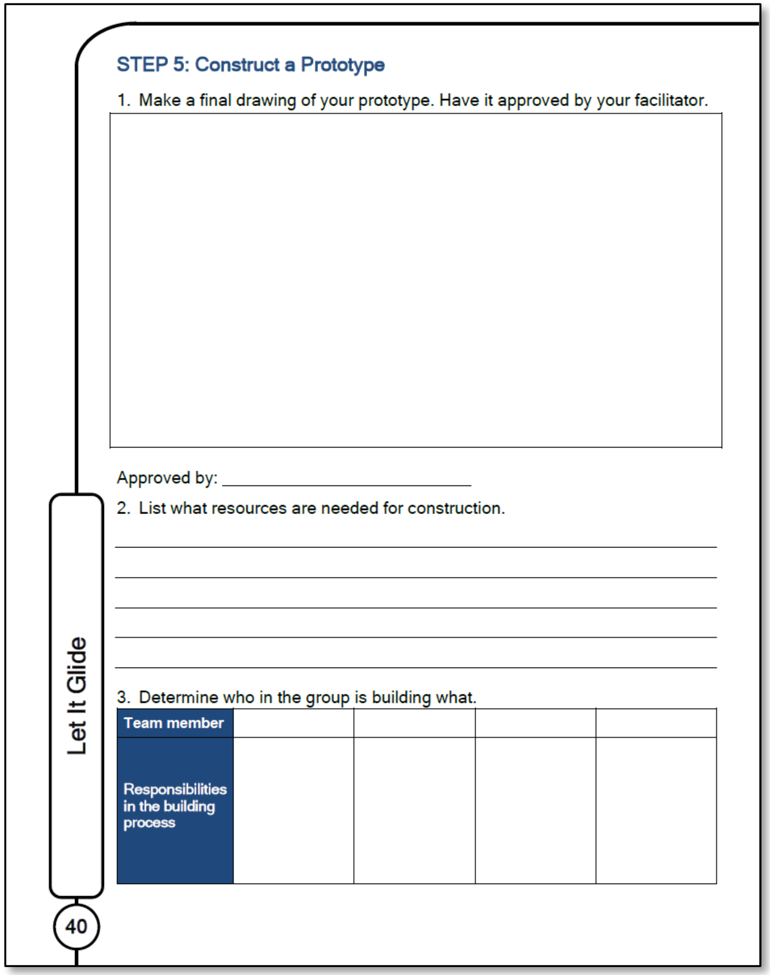
Work with your team to analyze each person's final drawing using the table below. Based on a team discussion, determine which design elements will be used to solve the problem, and what features will be included to create the team's prototype. The most promising solution may include elements from more than one design.

Design # Designer name	Does this design meet all problem criteria and constraints?	What are the strongest elements of this design?	What elements need to be improved?
1			
2			
3			
4			

Engineering Design Challenge

Step 5: Construct a Prototype

- Construct a model of the selected solution.
- What materials will be needed for each part of the assembly?
- Who will build each part?



STEP 5: Construct a Prototype

1. Make a final drawing of your prototype. Have it approved by your facilitator.

Approved by: ____________________

2. List what resources are needed for construction.

3. Determine who in the group is building what.

Team member				
Responsibilities in the building process				

Let It Glide

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Safety

Safety is priority #1.

- Safety goggles must be worn by anyone in the test flight area to prevent eye injury.
  “If it flies, protect your eyes.”
- Designs will be approved by your facilitator to prevent sharp or dangerous models.
- Keep areas cleaned up. Nothing on the floor or in the way. Report any dangerous situations immediately.

A NASA researcher wearing personal protective equipment (PPE) appropriate for his work in this lab at Kennedy Space Center; PPE should be selected to match the potential risks of the work to be done.

Step 6: Test and Evaluate the Solution(s)

- Test your team's model.
  - Stand at the start line
  - Measure what height you are throwing the glider from.
  - Throw the glider.
  - Measure how far the glider flew.
- How well did it fly?

STEP 6: Test and Evaluate the Solution(s)

Work with your team to record the data from each of your glide tests in the table below. Use a separate sheet of paper if more iterations are needed. **VERY IMPORTANT - Try to launch the glider using a smooth forward motion. Keep the force of the throw and the angle of release as constant as possible!**

Calculating Glide Slope
Glide slope is the path of descent for a glider. To determine glide slope, divide the horizontal distance traveled during the glide by the change in height (the vertical distance between the release point and the landing point).

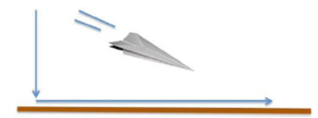


Figure 24: Glide slope.

$$\frac{\text{horizontal distance traveled}}{\text{vertical distance traveled}} = \text{glide slope}$$

Calculating Percent Change
To calculate the percent change between the current and original glide slopes:

1. Subtract the original glide slope from the current glide slope.
2. Divide the result by the original glide slope.
3. Multiply this result by 100 to express as a percentage.

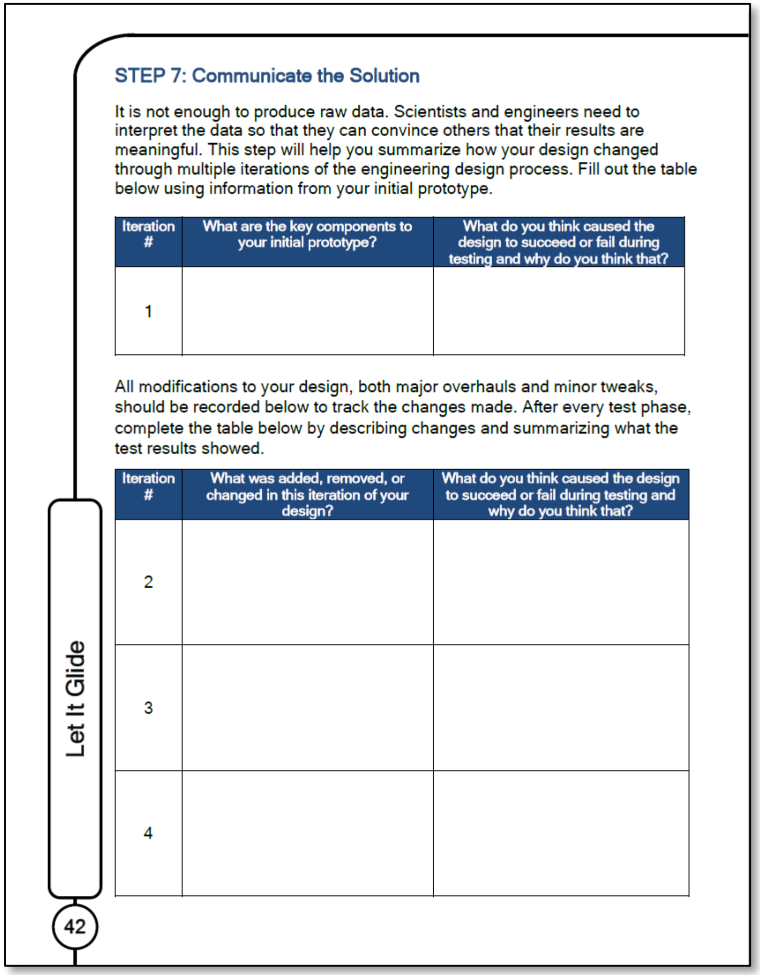
Positive results are an improvement; negative results show a decline in performance.

$$\frac{(\text{current glide slope} - \text{original glide slope})}{\text{original glide slope}} \times 100 = \text{percent change}$$

Iteration # Trial #	Horizontal distance	÷	Vertical distance	=	Glide slope	Best glide slope in iteration	Percent change from iteration #1
1-1		÷		=			
1-2		÷		=			
1-3		÷		=			
2-1		÷		=			
2-2		÷		=			
2-3		÷		=			
3-1		÷		=			
3-2		÷		=			
3-3		÷		=			

Step 7: Communicate the Solution(s)

- Record and share what your team learned about your design based on testing.
  - What worked?
  - What needs improvement?
- Talk with other teams to get ideas.



STEP 7: Communicate the Solution

It is not enough to produce raw data. Scientists and engineers need to interpret the data so that they can convince others that their results are meaningful. This step will help you summarize how your design changed through multiple iterations of the engineering design process. Fill out the table below using information from your initial prototype.

Iteration #	What are the key components to your initial prototype?	What do you think caused the design to succeed or fail during testing and why do you think that?
1		

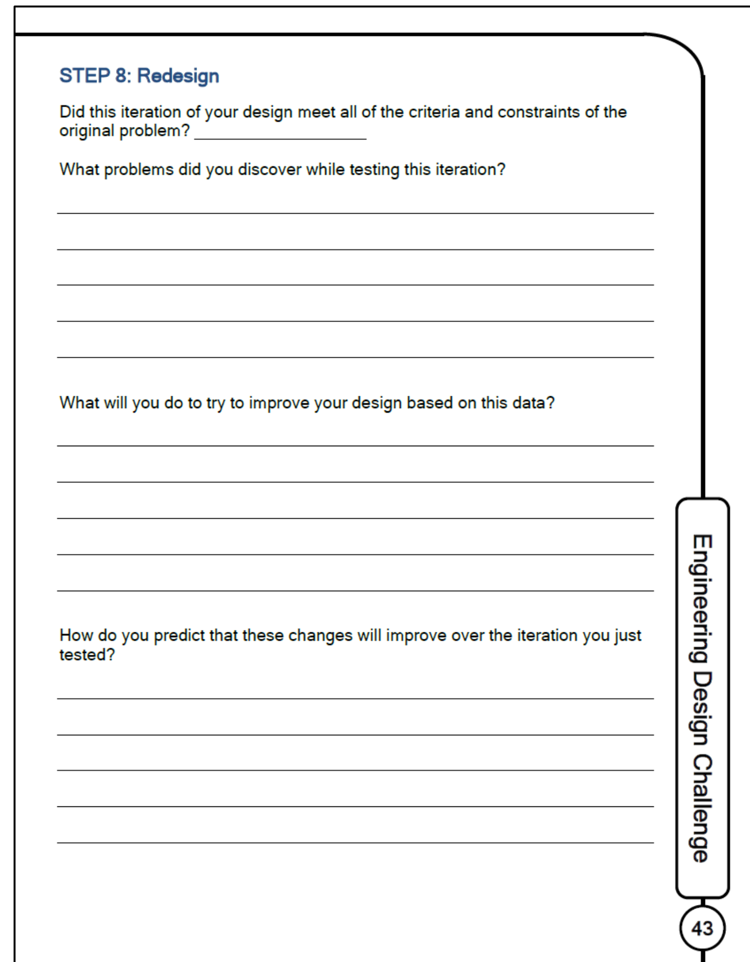
All modifications to your design, both major overhauls and minor tweaks, should be recorded below to track the changes made. After every test phase, complete the table below by describing changes and summarizing what the test results showed.

Iteration #	What was added, removed, or changed in this iteration of your design?	What do you think caused the design to succeed or fail during testing and why do you think that?
2		
3		
4		

Let It Glide

Step 8: Redesign

- What changes will your team make to your design to improve the glider?
- Does your new design still meet the criteria and constraints?



STEP 8: Redesign

Did this iteration of your design meet all of the criteria and constraints of the original problem? ______________

What problems did you discover while testing this iteration?

What will you do to try to improve your design based on this data?

How do you predict that these changes will improve over the iteration you just tested?

Engineering Design Challenge

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Debriefing Questions

- What were the greatest challenges for your team throughout this process?
- What strategies did your team use to overcome challenges?
- How did you use the Engineering Design Process to help with your design?
- What concerns must be considered in constructing a quality glider?
- What problems did you have to address while designing the glider?
- Would you like to be a pilot operating your glider on a scientific mission? Why or why not?

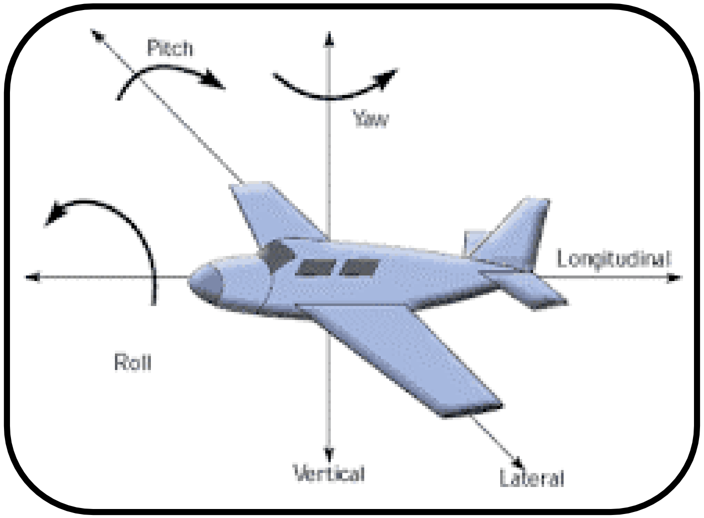
Lead-up Investigations

Investigation One – Exploring Glider Design

Investigation Two – Air Force Three

Investigation Three – Airfoil on a String

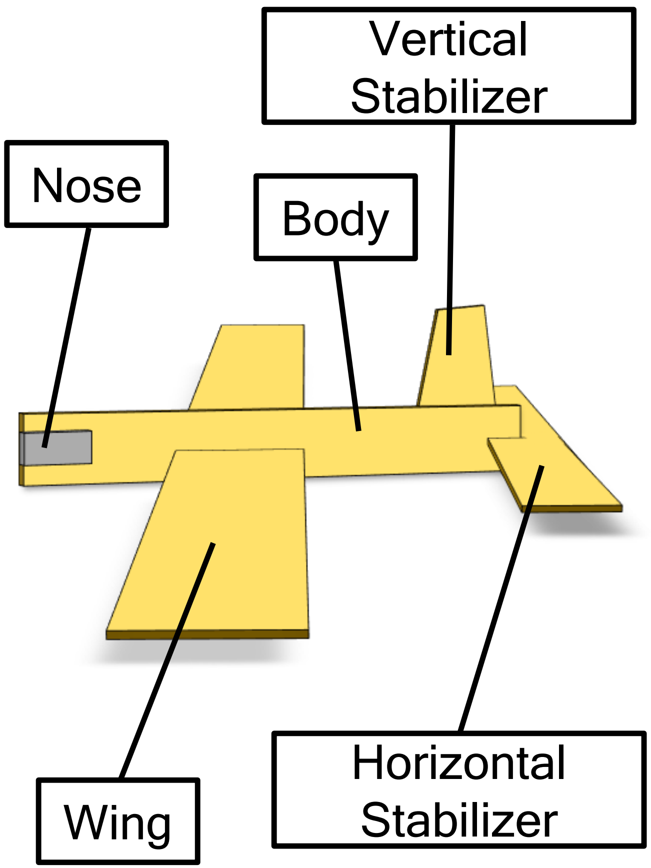
Exploring Glider Design



- As an aircraft moves through the air, it could deviate from straight-and-steady flight. When this occurs, the aircraft rotates around its **center of gravity**, the point where the weight of the aircraft is evenly dispersed and all sides are in balance.
- This rotation occurs in one or more dimensions at the same time:
  - Rotation around the horizontal (longitudinal) or x axis is called roll (clockwise or counterclockwise).
  - Rotation around the vertical or y axis is called yaw (left or right).
  - Rotation around the lateral or z axis is called pitch (up or down).

Connection to Let it Glide:
Determine how altering aircraft changes its aerodynamic properties and the way it flies.

Exploring Glider Design



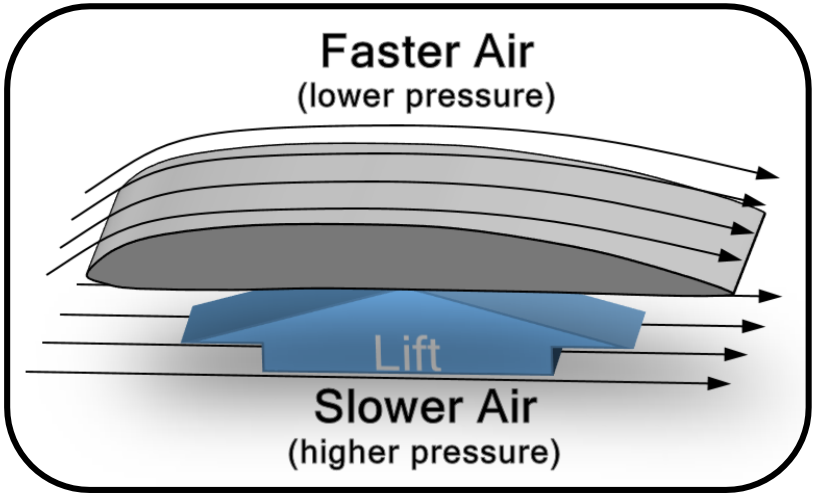
In this activity you will:

- Assemble the glider as the glider kit instructs.
- Throw your glider three times as control flights.
- Make one adjustment to the glider:
    - Slide the **wing** significantly to the left or to the right.
    - Slide the **horizontal stabilizer** significantly to the left or to the right.
    - Remove the **horizontal stabilizer**.
    - Remove the **vertical stabilizer**.
    - Change the location of the weight at the **nose**.
    - Remove the weight at the **nose**.
- Predict how this adjustment will change how the glider flies.
- Throw your modified glider 3 times and record results.

Air Force Three

Aircraft wings are often designed in the shape of an **airfoil** to improve lift by applying Bernoulli's principle:

- Faster moving air, exerts less pressure than slower moving air.
- Airfoils apply this principle to help create lift by increasing the speed of air moving over the wing compared to air moving under the wing.

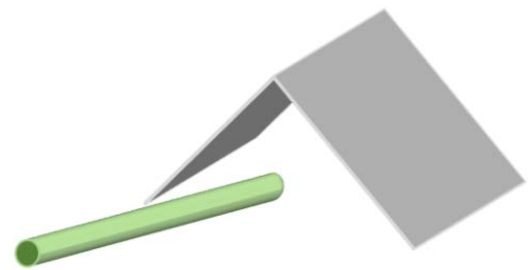


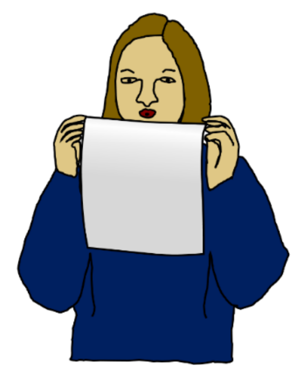
Connection to Let it Glide:
Determine how to generate lift by applying Bernoulli's principle.

Air Force Three

In this activity you will:

- Conduct three different demonstrations to show Bernoulli's principle in action.
  - *Tent with a straw* – Fold an index card in half to make a tent and place it on a desk. Blow under the tent through the straw.
  - *Two sheets of paper* – Hold one sheet of paper by the top edge in each hand. Position the sheets in front of your face with the side edges facing you. Space the sheets several centimeters apart and blow between them.
  - *Single sheet of paper* – Hold one sheet of paper by the top edge just under your bottom lip. Blow across the top of the paper.
- Predict what will happen before conducting each investigation.
- Observe and record what actually happened.
- Discuss all predictions and observations with other students.

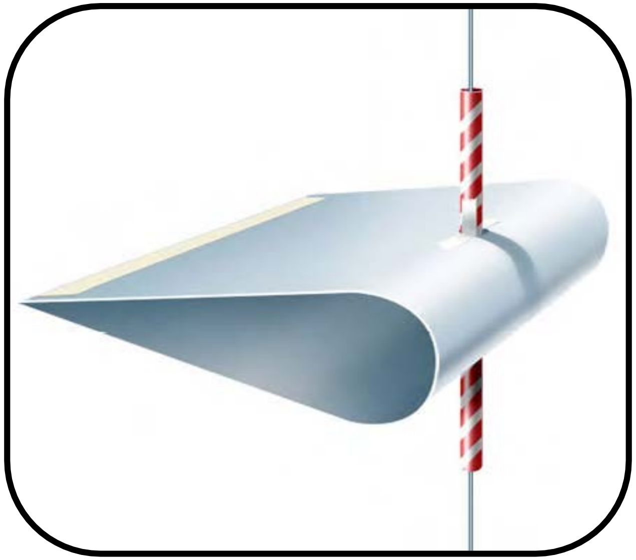




Airfoil on a String

An airplane wing can direct the air above and below based on the wing's angle of attack. This is an example of Newton's third law of motion:

- For every action, there is an equal and opposite reaction.
- Because the wing is symmetrical, Bernoulli's principle would not create lift. In this case, the wing must be tilted at a positive angle of attack to push air downward, creating upward lift on the wing.



Connection to Let it Glide:

Determine how to generate lift by modifying angle of attack.

Airfoil on a String

In this activity you will:

- Create the airfoil from the template provided and the instructions given.
- Slide the airfoil onto a string, holding the string at the top and bottom.
- Conduct the investigation with three angles of attack:
    - Place the wing level in front of the fan and observe and record results.
    - Tilt the wing upward by moving the top end of the string away from the fan. Observe and record results.
    - Tilt the wing downward by moving the bottom end of the string away from the fan. Observe and record results.