STEM on Site Summer Program

Glider Design Challenge

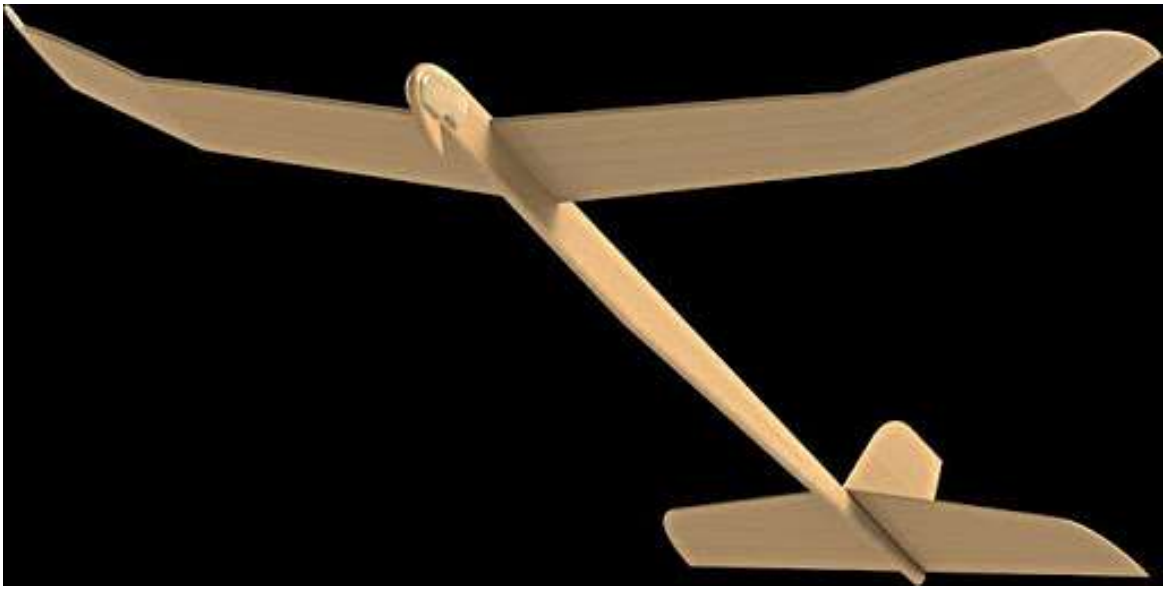


Image Source: Cudacountry Gliders

Recommended for Grade Levels: 9 - 12

Content Notice

This activity has been put together as a free, open source resource from the Milwaukee School of Engineering STEM team for self-guided, at home learning. Unless otherwise noted, in person or live instruction is not provided and questions should be directed to stem@msoe.edu.

Safety Notice

Parents or guardians should review activity materials before students begin the activity. Some activities from MSOE may require cutting, hot gluing, electricity, manipulating sharp objects, and other tasks that may warrant adult supervision. MSOE is not liable or responsible for any injury, property damage, or other incidents that arise from completing these activities at home. If you have questions or concerns about any activities, please contact stem@msoe.edu

Note about this Activity

This activity will provide guidelines and tips and tricks to enable a student to create their own design for a glider and then build this design. It will not provide step by step instructions and templates to build a glider, as the goal is for students to learn how to generate these items through the engineering design process.

What if I'd like to build a glider from a template first before trying to design one?

If starting from scratch with your own design seems daunting, we recommend this cardboard glider activity from Instructables.com. It's a quick activity that allows students to test out a glider design to help advise their own!

AMEDO also has a printable template and step by step instructions to build a glider here.

Goals

Design and build a hand thrown glider after learning about:

- Basic aerodynamic principles
- Components of a glider and how to optimize their design for flight
- How to create lift with wing surface design
- Tips and tricks for building your own glider

Looking for more advanced learning tools? Check out the background knowledge section for recommendations on how to take this activity further.

Learning at Home

While we have tried to select activities that utilize materials you might have around your home or able to procure without too much difficulty, we know that may not be the case for everyone.

One of our favorite parts of engineering is the problem solving and critical thinking skills required, and we encourage you to consider the following question when looking at the materials list for this activity:

If I don't have a certain material, what is the material being used for in this activity? Is there something else I could substitute that serves the same or a similar purpose? How can I modify this activity with what I have at home?

Materials

Recommended materials are listed below for this activity. Note that kits are not being sold for this activity through MSOE, as the cost to procure materials is lower direct from Amazon and other sources for families. We've hyperlinked some recommended materials that you may not have at home or be able to find at a local store easily.

	QTY	NAME
	4	8 x 11 sheets of building material, such as: Balsa Link (we recommend Midwest Products, but at the time of this writing they are out of stock) Cardboard – We recommend cereal boxes due to how light and thin the cardboard is Foam – This material will likely be the most difficult to work with. We recommend trying balsa or cardboard, but for students who may want to compare how different materials work, foam is a great choice!

REQUIRED TOOLS

	Writing tool for designing and graphing
	Hot glue guns or tacky glue
	Scissors
	Exacto knife - not required, but helpful – especially with balsa
	Protractor
	Ruler

Background Knowledge

Recommended Resources

Before starting the activity, we recommend checking out some of the following videos to provide useful background knowledge.

1. The Fundamentals | Glider Design – This video goes through some of the basics of glider design using a sample glider build. This video is also a great resource for sample designs to help you get started!

2. How Gliders Fly Without Propulsion – This video talks through how gliders fly without propulsion and how they differ from powered aircraft. It also covers design elements that should help in thinking about your own design!

3. Principles of Flight – This video is designed for pilots learning the fundamentals of aerodynamics. While this video is geared towards powered flight, it helps understand all of the forces and basics of flight

4. Parts of an Aircraft – This page from NASA's Glenn Research Center covers all of the parts and functions of an aircraft. This is more than you'll have on your glider, but this resource is critical to understanding what the parts of the glider are in the design guide later in this document.

Optional Resources

5. HowStuffWorks How Gliders Work – This provides a much more in depth look at full scale gliders and how they compare to aircraft

6. Advance Design Guide for Gliders – This resource may be much more detailed than what you'll need to complete you glider, but gives some good ideas for wing designs.

7. FAA Glider Handbook – This guide is designed for full scale glider aircraft from the Federal Aviation Administration. This is more information than students will need, but again provides a lot of useful information for designing a glider.

Advanced & Additional Resources

Maybe you've already built a glider before or you're looking to take this activity further – either way, here are some additional resources to help you continue your learning:

1. Building an Electric Glider – Take your glider to the next level and add propulsion! This video shows a much more complex glider design powered by a small electric motor.

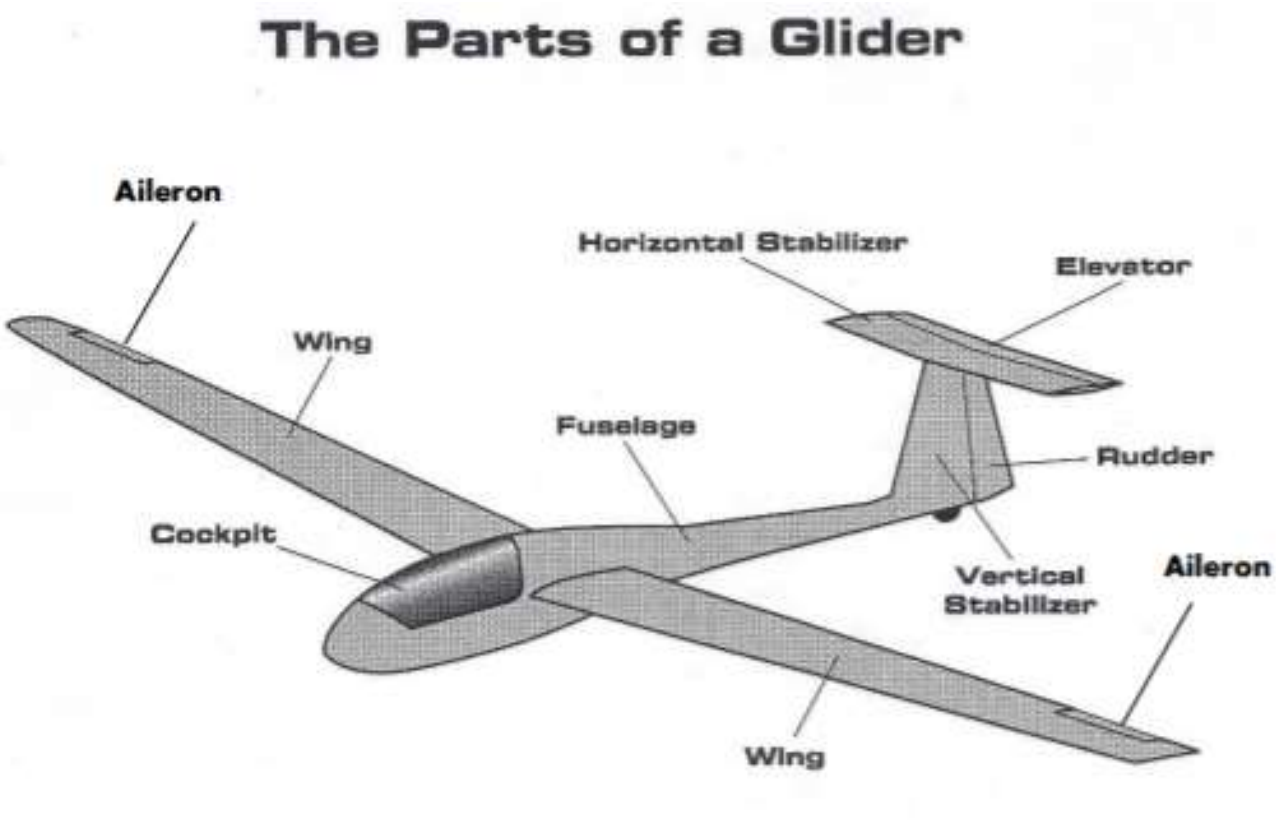
2. Design and Airfoil with FoilSim II – This resource from NASA's Glenn Research Center includes a foil design simulator along with activities and challenges around designing an optimal airfoil.

3. Nighthawk Gliders Balsa Glider Build – If you want to see a step by step balsa glider build, this is the video for you. They also have links to buy kits and plans if you're looking for additional resources.

Designing and Building Your Glider

Designing Your Glider

Begin sketching and thinking about your glider design – the table below is designed to help think through the elements of your design.



Source: Civil Air Patrol & AeroRacers Inc.

Look at the materials you plan to use before getting started. We are assuming you are building a glider that has a 2D fuselage (i.e. a single sheet of material versus building a box) and a 2D wing profile (i.e. a single sheet of material instead of an airfoil).

Component	Design Guideline	My Measurement
Wing Span	This is the total length from the tip of one wing to the tip of the other. We recommend no more than 12-18" for your first design	
Fuselage Length	65 – 75% of your wing span	
Fuselage Height	We recommend 2-3" at most	
Wing Width	We recommend at least using the width of your fuselage material in the widest part of your wing.	
Wing Area	Wing Width x Wing Span *If you have a unique wing shape, you may need to break it up into geometric shapes you are familiar with and then add the area of each of those shapes together.*	
Aspect Ratio	Should be between 4.5 and 7.5 *See breakout for calculating this below*	
Horizontal Stabilizer	20-25% of wing area *Hint: You'll come up with an area number and need to figure out lengths and widths that will enable you to get that area*	
Vertical Stabilizer	40-50% of your horizontal stabilizer area	
Dihedral Angle	5 degree maximum is recommended *See breakout for more information on dihedrals below*	

Wing Geometry

This guide from NASA's Glenn Research Center walks through how to calculate every aspect you could need for wing design. We've pulled a few of those topics below that are most pertinent to your glider design and shared them in a less detailed manner, but we highly recommend reviewing the guide from NASA's GRC linked above to understand wing design more fully.

Calculating Your Aspect Ratio (AR)

Your aspect ratio is an overall measure of how long and slender the wing is from tip to tip. You can use this equation to figure out what your aspect ratio is for the wing you've designed:

$$AR = \frac{(wing\ span)^2}{wing\ area}$$

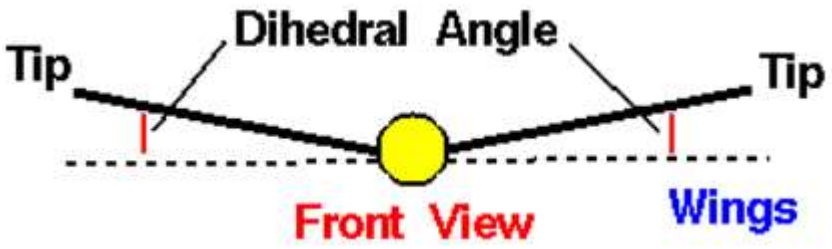
As with any equation, make sure all of your units are equal to ensure the value you get is correct!

Selecting Your Aspect Ratio

For gliders, an aspect ratio between 4.5 and 7.5 is recommended. Higher aspect ratios are typically seen in aircraft, such as gliders, that have long wing spans whereas a lower aspect ratio tends to be associated with shorter wing spans. The higher your aspect ratio, the lower the drag on your aircraft and the better glide angle will be which is ideal for glider design.

However, having too high of an aspect ratio can be detrimental to your design! The higher the aspect ratio, the longer and skinnier the wing is. Too skinny and long of a wing may not be able to support the weight of the glider.

Dihedral Angle



Source: NASA Glenn Research Center

The dihedral angle is the angel your wing makes relative the horizontal plane of your fuselage. It adds stability to keep your aircraft from rolling.

Building Your Glider

Many of the YouTube and reference videos linked showed time lapsed builds. Some things to consider as you build your glider:

- If selecting your own materials, cardboard, foam or balsa wood are great starting materials since they are light and easy to work with.
- Think about your adhesive choices. For example, super or modelling glue can disintegrate foam but may be a great fit for balsa wood aircraft.
- Where should the wing be? Right in the middle of the plane? Slightly forward? Test out different locations and try balancing the model on your finger tip. The center of gravity of your aircraft is the point at which you can balance it on your fingers and it won't tip forward or backwards. If your center of gravity is too far forward, your glider may take a nosedive when it begins flight!

If you have a glider build you'd like to share, send it to stem@msoe.edu and we'll feature it on our social media channels!