

# AMA BETA

BERNOULLI'S TEACHER NOTES & ACTIVITY

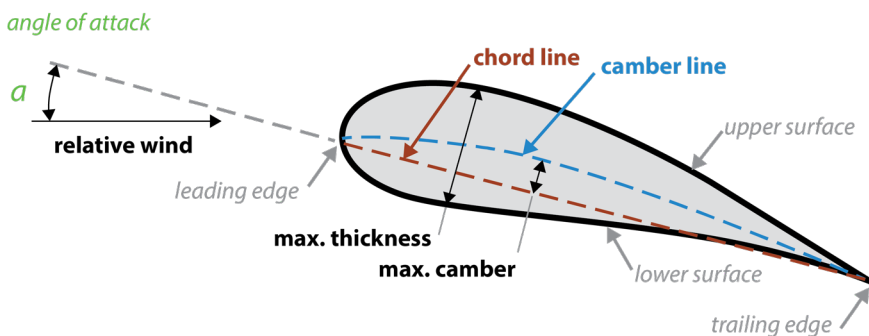


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## BERNOULLI'S PRINCIPLE AND LIFT

Clearly wings are the most crucial component for an aircraft's ability to fly, but how do they produce lift? It all has to do with their size and shape, the most important shape being the wing's cross section. Although they can vary widely across different types of airplanes, these cross sections all fall into a category of shapes called airfoils. The specific design of an airfoil might seem minor, but it is perhaps the single most consequential element of any given airframe.

To understand why, we need to look at how fluids, particularly air, behave. As discovered by Daniel Bernoulli in 1738, as the speed of a non-compressible fluid increases, its pressure decreases, and vice versa. When looking at an airfoil, we can see that the upper surface is curved, while the lower surface is flatter. This means that as the wing moves through the air, the oncoming airflow traveling over the upper surface has a greater distance to travel in the same amount of time than the lower air flow, so it travels faster. This creates a low-pressure area above the wing and a high-pressure area underneath it, producing an upward force or lift.



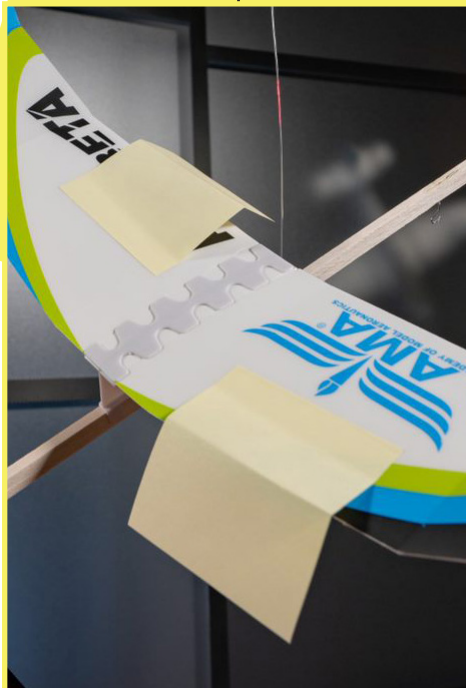
To explain this concept effectively, it might help to become familiar with the specific terminology related to airfoils and how they interact with the surrounding atmosphere. As a wing travels through the air, the edge directly meeting the oncoming airflow, or relative wind, is the leading edge, while the rear of the wing, where the airflows divided by the leading edge meet again, is the trailing edge. The chord line of an airfoil is the imaginary straight line that can be drawn between the leading and trailing edges, while the camber line is an imaginary curved line drawn between the same two points exactly halfway between the upper and lower surfaces of the wing. (You might notice that the BETA's wing has no flat lower surface, and thus no camber line.) The angle that can be measured between the relative wind and the chord line is the angle of attack, which is among the most crucial factors in the flight performance of an aircraft, and even its ability to stay in the air at all.

### WING MODIFICATION ACTIVITY

One of the parts that makes the BETA such a unique flying machine among rubber-powered aircraft is that its wings are molded into an airfoil shape, rather than being a flat plane of balsa wood or foam as in other models. Aerospace engineers who design aircraft take many different factors into consideration when designing the exact shape of the airfoils, such as what the aircraft's mission is and the performance that is expected from it.

The purpose of this activity is to make modifications to the BETA's premade airfoil to see if the performance of the plane can also be modified.

Example of how to increase or decrease angle of attack by modifying the leading or trailing edges



Example of how to increase camber by modifying the curvature of the upper wing surface.



## ACTIVITY OUTLINE

Students should divide into groups and make two to three test flights to determine their specific aircraft's performance characteristics. Test flights should be made with 600 turns on the winder.

Groups should discuss what modifications to the aircraft's performance they would like to attempt to make; these can include faster rate of climb, longer glide time, etc. These goals and modifications should be recorded in writing.

Using the materials provided, students can make (temporary) modifications to the airfoil of the BETA to achieve their desired performance characteristics, again making test flights with 600 turns on the winder. Record the results of each test flight in writing.

Modifications can include taping card stock tabs to the leading or trailing edges of the wing to increase or decrease angle of attack; increasing the wing's camber by taping curved pieces of paper to both leading and trailing edges; or anything else that does not permanently alter or damage the foam wing. See the attached pictures for suggestions, or feel free to get creative!

## MATERIALS:

- Card stock
- Printer paper
- Scissors
- Tape
- BETA aircraft

When/if the desired performance is achieved, the BETA can be flown with 800 turns.

*Do the same performance changes hold?*

*Why or why not?*

*What other modifications can help?*

Record these observations in writing. If time permits, remove the initial modifications, and pursue another set of objectives. Continue to record your findings.

