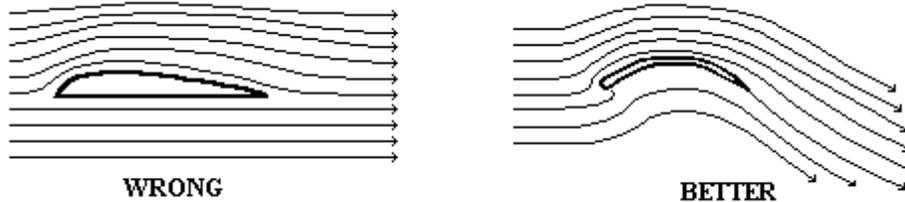


Airfoil Lifting Force Misconception Widespread in K-6 Textbooks



Beat around in the underbrush of aerodynamics and you'll encounter an interesting question:

HOW DO AIRPLANE WINGS **REALLY** WORK?

Amazingly enough, this question is still argued in many places, from elementary school classrooms all the way up to major pilot schools, and even in the engineering departments of major aircraft companies. This is unexpected, since we would assume that aircraft physics was completely explored early this century. Obviously the answers must be spelled out in detail in numerous old dusty aerodynamics texts. However, this is not quite the case. Those old texts contain the details of the math, but it's the **interpretation** of the math that causes the controversy. There is an ongoing Religious War over both the way we should understand the functioning of wings, and over the way we should explain them in children's textbooks. The two sides of the controversy are:

- **The physics explanation, NEWTONIAN or ATTACK ANGLE:** wings are forced upwards because they are tilted and they deflect air. A wing's trailing edge must be sharp, and it must be aimed diagonally downward if it's to create lift. Both the upper and lower surfaces of the wing act to deflect the air. The upper surface deflects air downwards because the airflow "sticks" to the wing surface and follows the tilted wing (this phenomena is called "Coanda effect" or "Flow Attachment.") After the wing has passed by, air remains flowing downwards. Airplanes fly because of Newton's 3rd law (action/reaction forces,) the law of Conservation of Momentum, and the Coanda effect.
- **The popular explanation, PATH-LENGTH or AIRFOIL-SHAPE:** wings do not deflect air, instead they are sucked upwards because the "airfoil" shape has a longer surface on top. Airfoils are curved on top and flat below, and therefore

the air follows a longer path above than below. Air that is divided at the leading edge of a wing must rejoin at the trailing edge. Since the upper surface of the wing is longer, it causes the air to flow faster over the upper surface, which (by Bernoulli's principle) creates lower pressure above. Because lift is caused by the shape of the wing, wings can create lift at zero attack angle. They can create lift simply from path length difference which leads to pressure difference, and no air needs to be deflected. After a wing has passed by, the air does not remain moving downwards. (THIS EXPLANATION IS SERIOUSLY FLAWED.)

(Note that the controversy extends far beyond grade school, and even some pilot training manuals still contain the discredited "path length" explanation.)

Also three *other* explanations of lift exist: the circulation explanation, the flow-turning or streamline-curvature explanation, and the vortex-based explanation. These three appear in advanced textbooks, where they form the basis of the mathematics used by aircraft designers. They rely on Bernoulli's equation. The misleading "popular" or "airfoil-shape" explanation commonly appears in children's science books, magazine articles, and in pilot's textbooks. On the other hand, the public rarely or never encounters explanations based upon circulation, upon curvature of streamlines, or upon Newton's Laws.

A possible solution to the controversy:

Billb's Airplane Flight Analogy

<http://amasci.com/wing/rotbal.html>

Note well: Newton and Bernoulli do not contradict each other. Explanations which are based on Newton's and on Bernoulli's principles are completely compatible. Air-deflection and Newton's Laws explain 100% of the lifting force. Air velocity and Bernoulli's equation also explains 100% of the lift. For the most part they're just two different ways of simplifying a single complicated subject. Much of the controversy arises because one side or the other insists that only **THEIR** view is correct. They insist that only a **SINGLE** explanation is possible, and the opposing view is therefore wrong. In other words... which is the One True Way to crack an egg? This is a war between the Big-endians and Little-endians from "Gulliver's Travels." They simply refuse to acknowledge that there are several valid yet independent approaches to solving the problem. They insist that their version must be the single right answer, the "One True Path," and anyone who disagrees is a heretic infidel who must be attacked and silenced.

Social psychology aside, there are also several serious mistakes usually associated with the "popular" explanation described above. Those who believe the "popular"

explanation are wrongly insisting that any parcels of air divided by the wing's leading edge must meet again at the trailing edge. This is incorrect; experiments easily show that the air above a wing far outraces the air below, and parcels never meet again. The same people also believe that wings fly only because of pressure, and that wings don't deflect the oncoming air downwards. Also incorrect. These and several other mistakes commonly appear in elementary science texts, as well as in popular articles on aircraft physics. These mistakes change the popular "airfoil-shape" explanation into a system of misconceptions. I explore these [below](#).

Also, those who firmly adhere to the popular explanation have been successful in convincing many authors that there can only be a *single* best method for explaining aerodynamic lift, and that the "Airfoil-shape" method is far better than the "Attack-angle" method. I strongly disagree with this, and believe that the correct versions of *both* explanations should be in constant use. Since the Newton method gives a better intuitive grasp of the issues, that method is more appropriate for elementary explanations aimed at the public and for introductory material for science students and pilots. On the other hand, the "Airfoil Shape" explanation is less intuitive, yet it dovetails very well with lifting force calculations, so it is very useful in mathematical modeling, for physics students, for aircraft design, fluid flow simulation software, etc.

The Truth shall set your free... But first it will piss you off!