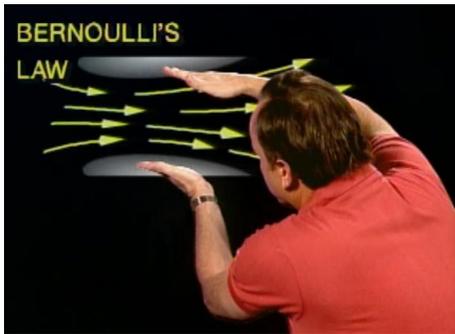


## Aerodynamic Lift – How it is created

**INTRODUCTION** Airplanes have now been flying for over 100 years. So one would think the theory behind how a wing generates lift would be very well understood by everyone in the industry. However, the popular explanation promoted in the current aviation literature, even supported historically by the FAA is misleading. Here is the popular explanation taken from **King's Private Pilot** ground school course.



The presenter starts with a venturi (A tube with a narrowed mid-section). The explanation rests of the assumed fact that air must accelerate through narrow region. According to Bernoulli's Law the pressure will drop in this region according to a well defined mathematical formula. This creates a pressure difference from the upper to the lower wing surface.

The problem is that experiments which match up with this theory show that this effect only accounts for about 25% of the lift being generated by the wing. So what generates the bulk of the lift.

**DETAILS OF THE MORE COMPLETE THEORY OF LIFT** As a kid most of us have stuck our arm out the window of the family car while going down the highway. You probably found your hand could generate lift and yank your arm up uncontrollably. Obviously your hand did not have a nice airfoil shape, but it generated considerable lift anyway.

The ground school presentation referenced above goes on with this next picture. Notice the Yellow arrow (I've added these to the picture) on the left aligned with the on-coming airflow. The one on the right is aligned with the airflow departing the wing. The difference in direction, shown by the red lines (I've also added the red lines to the picture) is the shift in direction of the air approaching and leaving the wing. The resulting down flow is

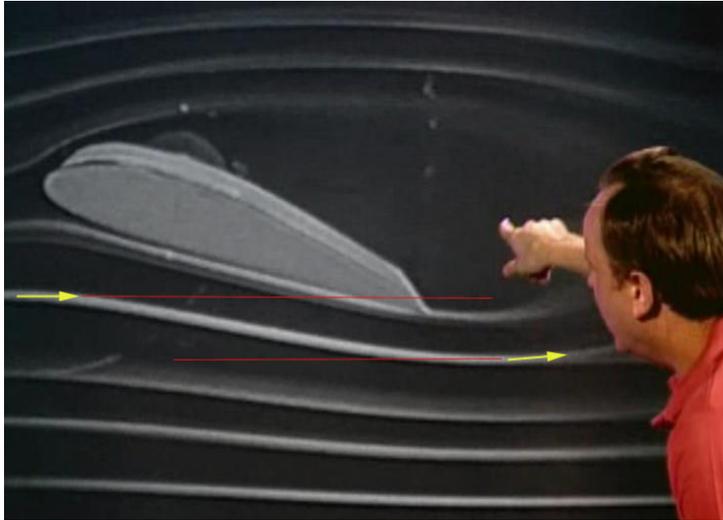


called *Downwash*. The answer to how the bulk of the lift is generated is latterly right under this guys nose, but he is pointing to the top of the wing. Experiments have shown that the overall downwash flow generates about most of the total wing lift.

If you interested in further reading check out **Introduction to Aerodynamics** by Gale Craig 2002, Regenerative Press, or his earlier book **Stop Bashing Bernoulli – How Airplanes Really Fly** (ISBN 0-

0646806-2-9).

**THE STALL** It's interesting to look at this same presentation of lift as it goes on to discuss the stall. The following picture is from a later sequence. Note the Yellow arrows (that I've added to the picture) lined



up with the in-coming and out-going airflow. There is no downwash angle, so the bulk of the lift is gone. Yet the presenter is still pointing to the top of the wing.

So why does the industry continue to perpetuate this misconception. The answer is probably that it simple and can be made easily understandable.

The latest **Pilot's Handbook of Aeronautical Knowledge** (FAA-H-8083-25A) published 2008 finally has a more

complete explanation of the theory.

**SUMMARY** Take some time to review NASA's paper on lift at <http://www.grc.nasa.gov/WWW/K-12/airplane/bernnew.html> . You'll find that the explanation is much richer and more complete that the over simplification that has been presented in most pilot literature. This may not help you fly an airplane any better, but a deeper understanding of how airplanes fly should be beneficial to you aviation experience.