

Plausible falsehood is still being taught. Aerodynamics teaching at grade through high school level, as well as teaching at college level, is seriously flawed. The most popular lower level theory of wing operation, which we may call Hump Theory because it requires a wing to have a more convex upper surface as compared to the lower, is easily shown to be false. Hump theory is based on the Bernoulli theorem, according to which pressure and velocity are inversely related, and on a principle of equal transit times, according to which air passage over an upper wing surface must occur in the same time as air passage below. If both of these premises are valid, then in order to have the same transit time, flow at a more curved upper wing surface, having a longer path, must be of greater velocity than that at a less curved lower surface, and upper surface pressure must then be less than that at the lower in accordance with the Bernoulli theorem. Unfortunately, the premises are not both valid.

Hump theory does not allow for balsa toy gliders with flat wings which fly quite well, and it does not allow for inverted flight of aerobatic airplanes. For a mathematical proof that the theory is false, consider one the most popular trainers, the Cessna 150 or 152, which has wings of 160 square feet total area, upper surface path about 1.6 percent longer than the lower, and can fly at 55 miles per hour. Calculated according to hump theory, lift at that speed would be about 40 pounds, a small fraction of the 1600 pounds rated gross weight of the airplane. Calculated minimum flying speed for the airplane according to hump theory is over 300 miles per hour, well above the redlined dive speed of 160 miles per hour.

The problem with hump theory is in the assumption of equal transit times, which has no basis in known physics, and is quite wrong. In fact, upper surface transit time in normal flight is always less than that below. Despite being quite wrong, this theory of flight is still being included in books from otherwise reputable publishers such as National Geographic, Macmillan and others in this country and abroad.

Aerodynamic lift of a wing can be explained and calculated through simple application of Newtonian physics. In a perspective of a stationary lifting wing in passing air flow, the flow, through "flow attachment" otherwise known as "Coanda effect," follows the contours of the wing so as to depart in a somewhat downward direction pointed by the converging aft surfaces. In a different, but equivalent perspective, an airfoil moving horizontally through still air leaves air at the trailing edge moving nearly vertically downward behind the converging upper and lower surfaces. In either perspective, direction of air into downward movement continuously produces downward air mass momentum which is left behind. Upward reaction force (or lift) is equal to the downward rate of change of air momentum, in accordance with Newtonian principles.

Pressure reduction at the upper surface is due to an upward centrifugal pressure gradient in the downwardly curving flow. This gradient opposes atmospheric pressure and causes upper surface pressure reduction. At the lower surface, pressure increase occurs as the lower surface pushes air down to also produce an upward pressure gradient increasing lower surface pressure.

These effects can be demonstrated by blowing air over a sheet of paper which droops from the horizontal. Air blown over the upper surface so that flow curves downward produces an upward centrifugal pressure gradient opposing atmospheric pressure, causing upper surface pressure reduction and lift. If air is blown beneath the paper, then the upward pressure gradient in downward curving flow adds to atmospheric pressure at the lower surface pressure to again produce upward lift.

Understanding of recirculation is the key to understanding effects of wing sweep, washout, taper, aspect ratio, camber and span. A more complete story is presented in forums at EAA Oshkosh convention and Lakeland Sun-N-Fun. The 1999 Oshkosh forum will be on July 30th at 7PM and the Sun-N-Fun forum will be April 16th at 1 PM. A detailed 160 page book on the subject with over 100 illustrations, titled "Stop Abusing Bernoulli!- How Airplanes Really Fly," ISBN 0-9646806-2-9, is available from WWW.Amazon.com, WWW.BarnesandNoble.com, or from The Academy of Model Aeronautics museum bookstore, phone 765-287-1256 ext. 501.

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