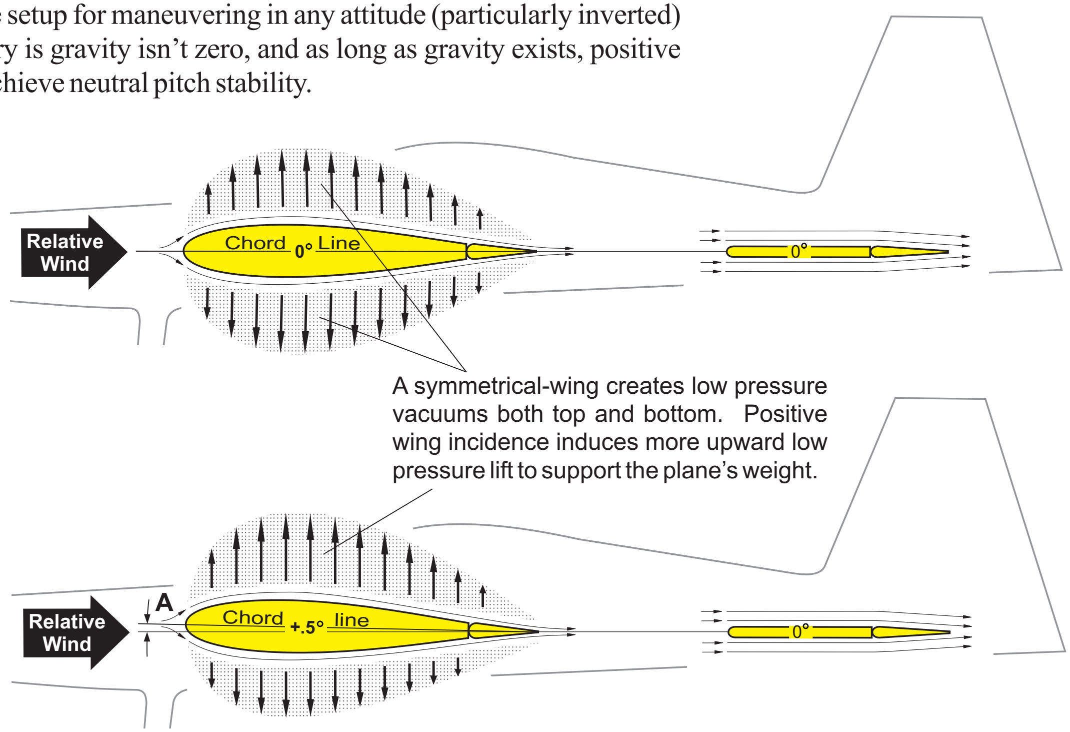
Wing Incidence (a.k.a., Decalage) Primer

Achieving a high degree of "neutral" pitch stability, that is, the ideal tendency of an aerobatic airplane to stay in the attitude it is placed in until changed by the pilot, is largely determined by whether or not the airplane incorporates positive wing incidence. The omission of positive wing incidence on many models designed since the 1990's has made it necessary to cover this crucial subject which had been a fundamental design feature for most of the sport's history. With a few exceptions, such as Hanger 9 & Carden Aircraft, the steady disappearance of positive wing incidence in radio control aviation is rooted in the persistent theory that the ideal airplane setup for maneuvering in any attitude (particularly inverted) is to have everything set at zero! The problem with that theory is gravity isn't zero, and as long as gravity exists, positive wing incidence will be necessary to generate upward lift and achieve neutral pitch stability.

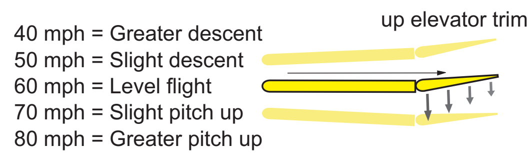


Explained: Air flowing over the curved surface of the wing generates a low pressure vacuum (suck). A symmetrical airfoil wing will produce an equal amount of low pressure on both the top and bottom at zero angle of attack to the relative wind (direction of flight).

The "chord line" is the line running from the trailing edge of the wing through the center of the leading edge. "Angle of attack" is the angle of the chord line to the relative wind.

As a rule, the horizontal stabilizer will fair (align) with the relative wind, thus, a symmetrical wing set at the same angle as the stab produces no upward lift to support an airplane's weight. Positioning the wing at a slightly positive angle of "incidence" (**A**) or "decalage" relative to the horizontal stabilizer results in greater low pressure on top of the wing and thus the lift needed to support the weight of the plane.

When positive wing incidence is absent, pilots must alternatively trim the nose UP to establish a positive angle of attack to maintain level flight. However, using elevator trim this way only works in theory if the plane's airspeed remains constant. Since the airspeed is constantly changing during flight, the force exerted by the elevator trim on the tail will be constantly changing as well. I.e., as airspeed increases, the increased effectiveness of the trim will cause the airplane to pitch up. As the airspeed slows and the effect of the trim becomes less, the plane will pitch down. Consequently, airplanes with the wing set at the same angle as the stab display subtle but erratic pitch tendencies because they constantly go in and out of trim.

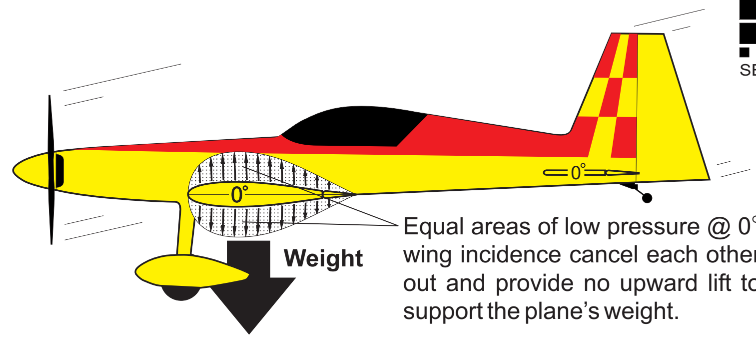


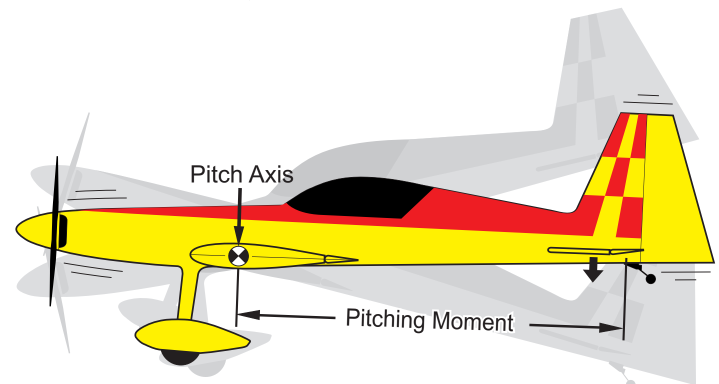
Positive Wing Incidence = Neutral Pitch Characteristics

The absence of positive wing incidence on many aerobatic models today, due in part to the theory that this will improve inverted performance, makes those planes more demanding to fly due to the changing effects of having to use up elevator trim to generate lift. Because it's not feasible to constantly re-trim, a pilot flying an airplane without wing incidence ends up having to make constant pitch corrections just to keep the plane level or on a line. While the popular response is to add more radio exponential (expo) to tame some of the instability, adding large amounts of expo doesn't address the fundamental cause of the instability and ultimately introduces additional variables.

Building a 1/2° of positive wing incidence/decalage into a plane relative to the stab provides the upward lift needed to support an airplane in flight. And since the lift is being generated by means of incidence (as opposed to using elevator trim), speed changes while maneuvering do not result in undue pitch changes. The result is an airplane that is just as capable, yet less demanding to fly and thus more conducive to rapid advancement.

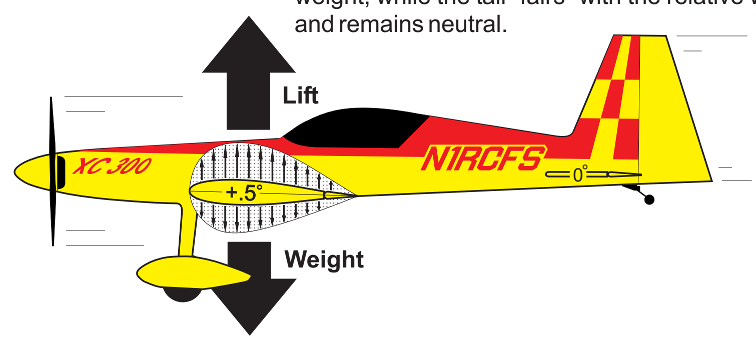
It's important to note that manufacturer's efforts to improve inverted performance by omitting wing incidence are negated by the UP elevator trim put in to maintain level flight when upright, so about the same amount of forward elevator pressure is needed with or without wing incidence. FYI. Achieving inverted flight requiring little or no forward elevator is not a function of incidence, but of balance! That's why DOWN trim is sometimes necessary--even with zero wing incidence--in order to compensate for tail heavy setups intended to improve inverted performance. But all that really does is cause the same pitch instability and trim problems previously described, except in this configuration the plane pitches up when speed is reduced, and pitches down when accelerating.





The effect of using trim to sustain level flight only works at a constant speed. Changes in speed cause the trim to become more or less effective, thus causing the tail to pitch up or down.

1/2° positive wing incidence built into an airplane produces the upward lift that supports the plane's weight, while the tail "fairs" with the relative wind and remains neutral.



KPTR: Wing incidence helps turn what would otherwise be an unstable airplane, into a more neutral, honest, and predictable one!

Checking Wing Incidence

DAS
SETUP

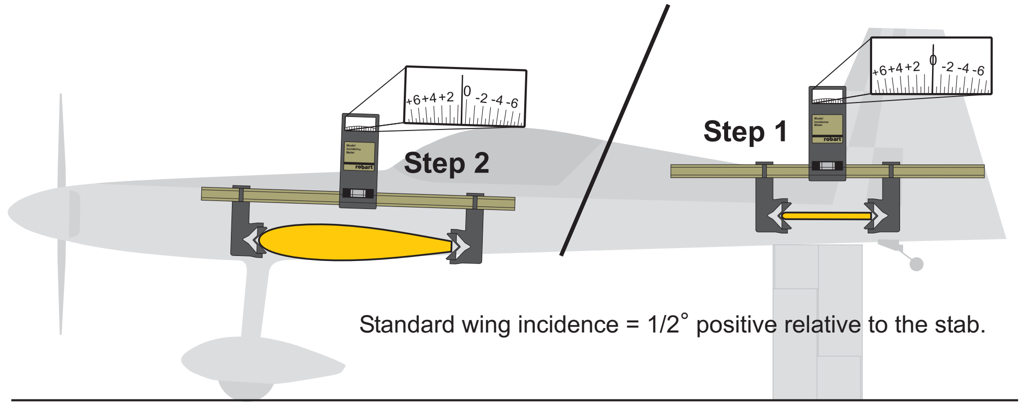
The wing incidence rule-of-thumb aimed at achieving “neutral” flight characteristics is 1/2° positive relative to the stab. You would frankly have to pilot hundreds of aerobatic models over thousands of hours to detect whether occasionally a plane would be slightly better off with .4° or .7°. The 1/2° rule will always be within 95 to 100% of optimum.

Step 1: Slide an incidence meter onto the horizontal stabilizer and note the reading.

Step 2: Check the wing, and whatever the stab reads, the wing should be 1/2° more. (Ideally, the incidence would be checked before gluing on the control surfaces, but if already assembled, take your readings with the control surfaces as neutral as possible.)

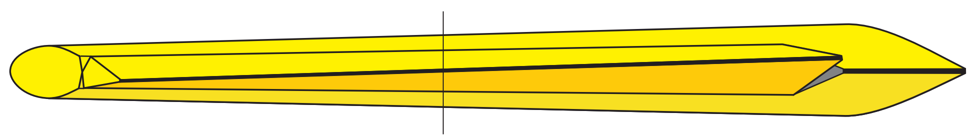
If an airplane is deemed to be unstable at the flying field due to a lack of wing incidence (and not an aft C.G.), it can be put in knowing that a 1/2 degree (actually .6) measures out to be a 1/16″ at a 6″ arm, and a 1/8″ at a 12″ arm. Thus, if the trailing edge of the wing is 12 inches behind the wing’s fixed pivot point (e.g., wing tube), lowering the trailing edge of the wing an 1/8″ increases the incidence .6 degrees.

In the event that your model does not have positive wing incidence, adding a 1/2 degree to avoid pitch instability is simple to do either by relocating the holes for the 2-piece wing anti-rotation pins, or lining the wing saddle with balsa to create a new saddle.

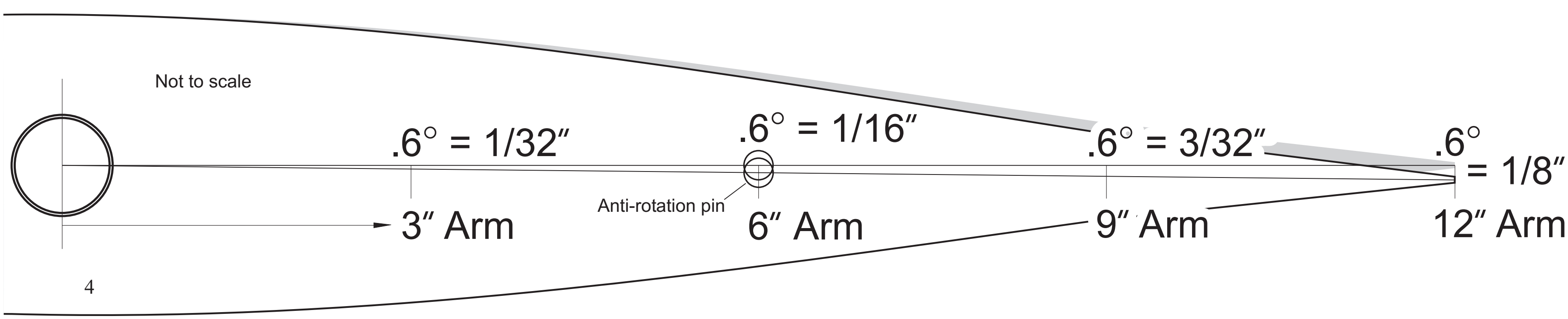


Standard wing incidence = 1/2° positive relative to the stab.

NOTICE: Most wood ailerons and elevators are inherently twisted for part or all of their length. Thus, incidence readings should be taken at several locations along the length of the structure to come up with the true (average) incidence.

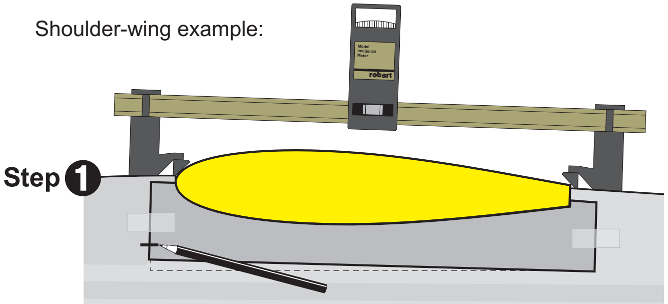


Twisted (full length) aileron example: <u>True</u> wing incidence taken at the half span point.

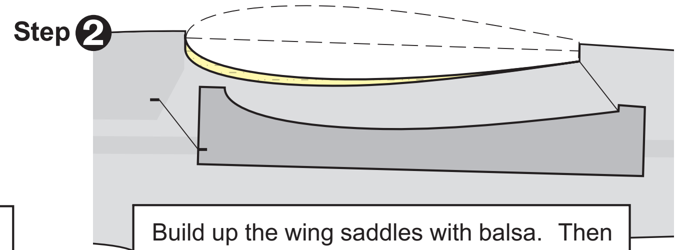


Wing Saddle Modification and Common Wing Incidence Questions

Shoulder-wing example:

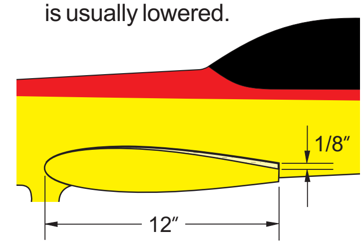


Make a cardboard template of the original wing saddle. Tilt the wing to where it reads 1/2° more than the stab. Place the template up to the wing and mark its position on both sides of the fuselage.



Build up the wing saddles with balsa. Then secure the template into position and cut along the template with an X-Acto knife to make the new saddle.

The process is the same for low wing airplanes, except the trailing edge of the wing is usually lowered.



Q. Will positive wing incidence make it tougher to fly inverted?
A. No, but forward elevator pressure will be required. Ironically, attempts to get airplanes to fly inverted with very little forward pressure by placing the wing at zero incidence are negated by the UP elevator trim that's required to maintain level flight when upright, so about the same amount of forward elevator pressure is needed with or without positive wing incidence. FYI. Many pilots feel that having to hold in some forward elevator pressure inverted has its advantages, such as providing a pilot with a better feel for what he's doing, and he'll seldom get confused about which way to apply the elevator if he's already holding some in.

Q. Does less (zero) wing incidence make an airplane more maneuverable?
A. Not necessarily. Wing shape and position relative to the C.G., moment arms, tail size, control throws, weight, and balance primarily dictate an airplane's maneuverability. Zero wing incidence does nothing to make an airplane more maneuverable, other than making it less stable, and therefore a bit more inclined toward wild stunts (which some obviously prefer). In a nutshell, airplanes with positive wing incidence are just as maneuverable as those without, and better suited for precision aerobatics, takeoffs, and landings.

Q. What would happen with more than 1° of incidence?
A. The wing would generate too much lift at high speeds and thus require down trim or excess down thrust. Too much positive incidence would require down trim at high speed to keep from climbing, creating the same trim problems and pitch instability during speed changes as those encountered with zero incidence, but reversed: Decelerate = pitch inside. Accelerate = pitch outside. Contrast that to the neutral stability achieved using the 1/2° rule in which a pilot enjoys thinking less about how the airplane is behaving, and more about what he wants to do with it!

Q. Does airplane size make any difference?
A. Yes, larger planes have more mass inertia to help steady faulty aerodynamics. While it's possible for larger planes to overcome some aero-defects at higher speeds, instability issues will increase when the plane is slowed down with less inertia, such as during landing. *The simple fact is that sound aerodynamic principles remain sound principles regardless of whether it's a NASA wind tunnel model (large or small), radio control, or man-carrying aircraft.*

Q. Can I change the stab angle instead of the wing?
A. Yes, but there's more to it. Changing the stab angle would also require adding more down thrust, as well as cause the airplane to have the appearance of flying slightly tail low/nose high.

Q. Why don't the designers put wing incidence back into their plane's?
A. Flyers have assumed the burden. Lack of wing incidence is seldom identified as a source of trouble, since it's so natural to assume that inconsistencies while flying higher performance airplanes is simply the need for more practice, additional programming, wind gusts, radio glitches, etc.. Plus, all those whose flying skills have hit a plateau often prefer tinkering with their equipment more than seeking to optimize the setup for the best possible results in the air. Also, positive wing incidence is aimed at improving precision handling, thus, 3D oriented designers/pilots see little need for it because they "fly more on the prop than on the wing!"

Q. My plane came from a company that's designed a lot of planes, so wouldn't they know if incidence was needed or not? The objective here has been to stress that the proper wing incidence helps reduce the pilot's workload to only what is essential for performing the maneuvers. The principles behind installing wing incidence are common knowledge in full-scale aviation, and therefore if you're interested in learning more, search full-scale resources for info on Centers of Pressure, Pitching Moments, and Dynamic Stability, and you'll know more than most in the sport.