Centered for Success – Solid flight performance starts with getting the CG right

Balancing a new model correctly is the most important thing to flying it successfully. Whether you fly a basic trainer, a sport plane, or a t powered jet, if its center of gravity (CG) isn't right, you won't have a good first flight! Let's find out why. I promise not to make you do mat

STABILITY & LIFT

If you build a model from a kit or assemble an ARF, the figuring out will have already been done for you. All you have to do is read the di and make sure your model's balance point is at the location specified. Why is it so important? The answer is stability.

To oversimplify, all airplanes have a center of gravity and a center of lift. Their positions relative to each other are what make a model st unstable. "Static stability" refers to a model's response to an alteration in pitch, roll, or bank angle. "Dynamic stability" refers to a model's response over time—what it does and how long it does it before it returns to a stable condition.

Stability is realized in all three major axes: longitudinal (pitch), lateral (roll) and directional (yaw). In this article, the placement of the CG c specifically with longitudinal stability as it affects pitch and the model's angle of attack, which directly affects the model's stalled and un- flight conditions.

For most sport planes, the CG is the point at which the model balances longitudinally (nose to tail), and its position is affected (fore and a its weight distribution and that of its various parts, i.e., engine, fuel tank, receiver, servos, landing gear, etc. The model's center of lift is tl

(MAC.)

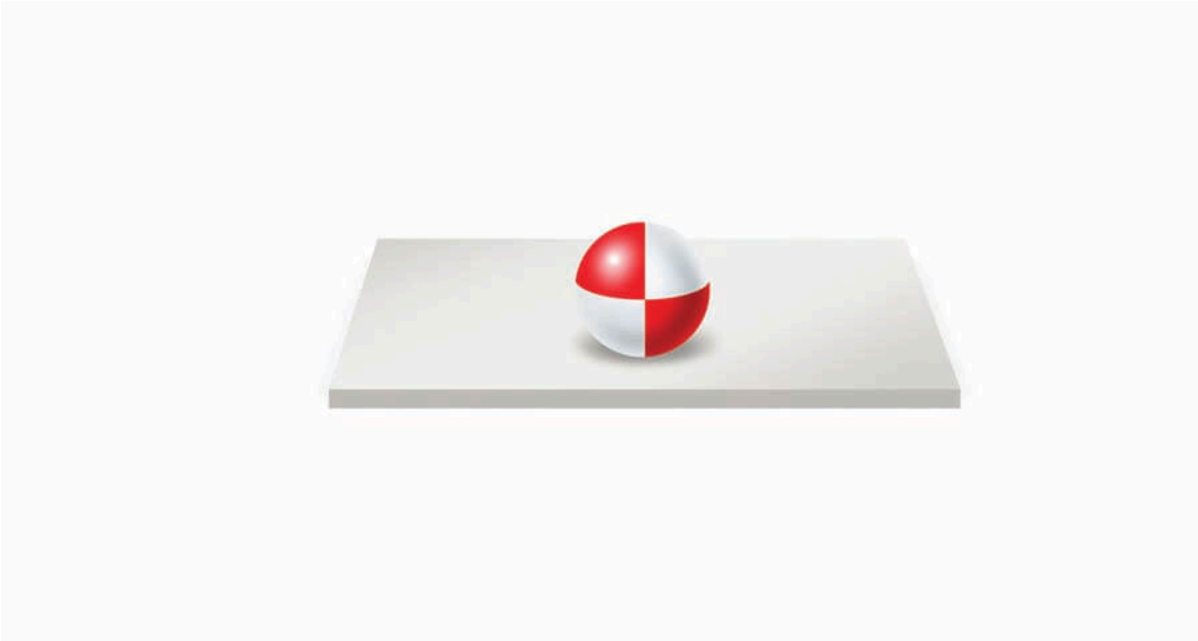
TRIAD OF STABILITY

Stability, specifically dynamic stability, falls into three categories: positive, neutral and negative. When a model is positively stable, it tenc right itself after being moved from its flight path. If you raise the nose and let go of the elevator stick, the model will lower its nose and r level flight. The nose will fall and pitch downwards, and then oscillate up and down before it zeroes in on the straight and level flight patl started at.

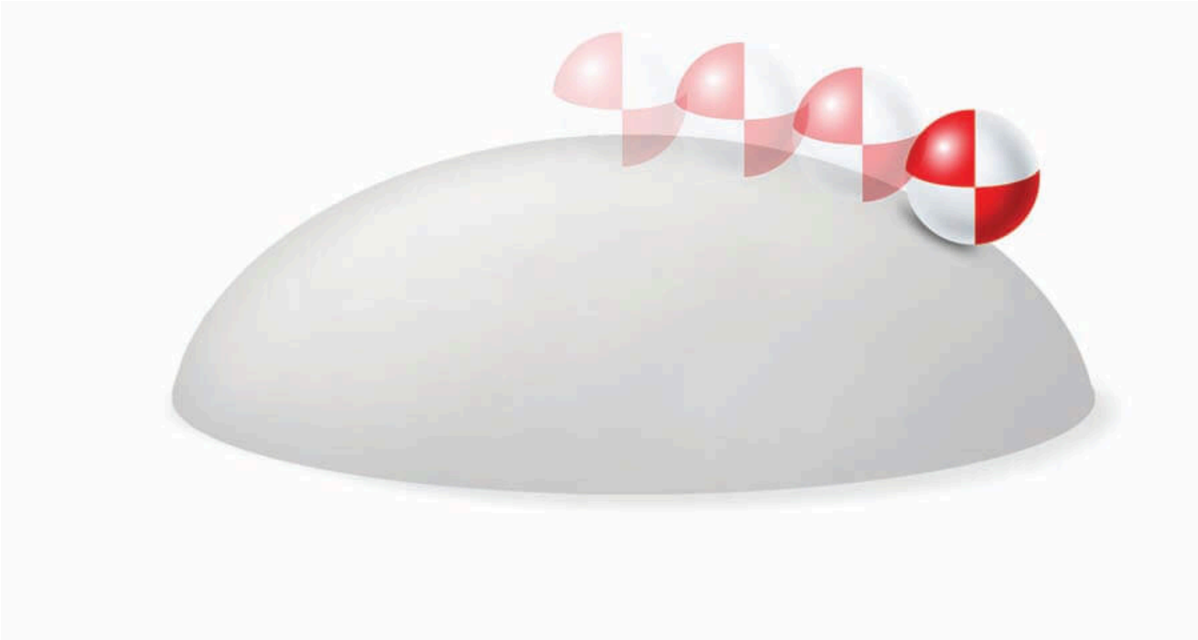
You can visualize this with a ball in a round bowl. Place a ball in a concave bowl, move it to the bowl's rim and let it go. The ball will roll ba forth until it returns to the bowl's bottom center. A model that has neutral stability, once moved from a certain flight attitude, will tend to remain in its new position. This is like a ball on a flat, level plate; move the ball and it stays where you put it. When a model is negatively s when you move it from a straight and level attitude and let go of the stick, its nose will oscillate up and down with each cycle continuing increase its disturbance away from the stable state. To keep with our bowl analogy, it would be like taking the bowl and turning it upside to make it a dome. Place the ball at the very top and push it. The ball quickly falls away from its starting point.

Positively Stable

Less Stable

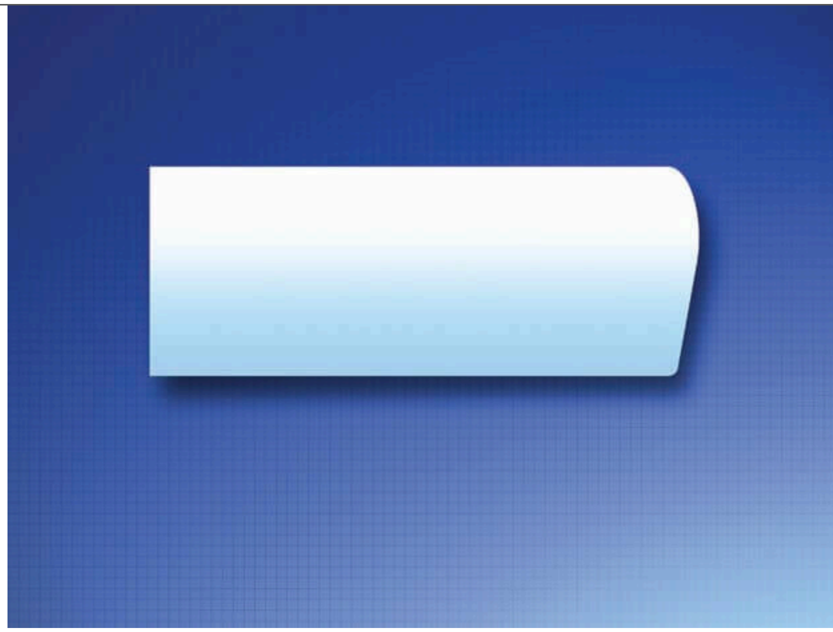


Neutrally Stable



Negatively Stable

So, what does all this all mean? For starters, you can begin by placing the CG at the 25-percent MAC point to produce a model that is pos stable. This position is ideal for trainer aircraft, and it's where you should balance a new model for its very first flight. Moving the CG forv from that position increases stability up to a certain point, but then the model becomes too nose-heavy. Moving the CG aft to the 30- to percent MAC lessens stability, and right around 35-percent MAC, the model becomes neutrally stable. This is where sport aerobatic mod should be balanced. Moving the CG farther back, say to 40-percent MAC, is good for 3D aerobatics, but any farther back, and the model becomes negatively stable—not a good condition for any type of model.



When the wing has a constant chord, the wing chord (distance from leading edge to trailing edge) and the mean aerodynamic chord (MAC) are the same. On most models, the CG should be between 25 and 33 percent of the MAC back from the leading edge

FINDING THE MAC

To properly set the CG, you first have to find the mean aerodynamic chord (MAC). The position of the MAC depends on the layout of the wing panels. There are basically three panel shapes: a straight, constant-chord wing as shown in Figure 1; a tapered wing panel where th wingtip is smaller than the wing root (Figure 2), and a swept wing panel where the trailing edge of the wingtip is aft of the root rib's trailir (Figure 3).

A straight wing is easy because the MAC and the wing chord (the distance from its leading edge to its trailing edge measured parallel to i rib) are the same. For a tapered wing and a swept wing, how- ever, the MAC is moved aft a certain amount (to establish its position, refe Figures 2 and 3).

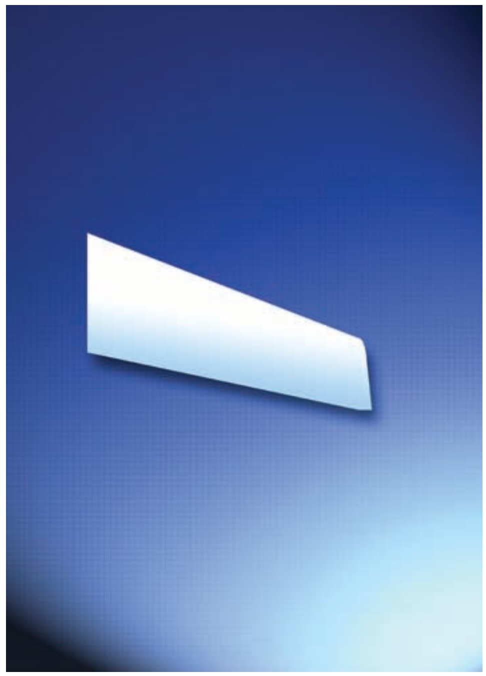
Welcome, ROBERT VALENTINE

To find the MAC of a tapered wing, extend the root and tip measurements fore and aft and connect the ends with projection lines as shown. Where the lines cross, draw a line parallel to the root rib. This is the MAC position. The CG should be between 25 and 33 percent of the MAC measured back from the leading edge. Measurement lines can be projected 90 degrees from the MAC/CG positions to show the balance points at the root and tip ribs.

You can do this by placing your model's right wing panel on a piece of graph paper, tracing around it and then drawing the root and tip-e parallel with each other. Measure the length of the root rib and label it "A." Measure the tip rib and label it "B." Easy enough; no math—ju measurements. Now take the root A measurement and draw a straight line extending forward from the front of the tip rib line B. Do the aft of the tip rib B and extend it aft. Now repeat the process at the root rib line A with two extension lines B extend- ing forward and aft. yardstick and connect the end of the forward-most root extension line with the most aft point of the tip extension line. Do this again fro forward-most end of the tip extension line and the rear-most point of the root extension line. This forms a big "X," and where the two lin is the point at which you draw the MAC line. Draw it from the wing panel's leading edge to the trailing edge, making it parallel with the rc line by 3 to find the 33-percent MAC point. As an example, let's say the MAC is 10 inches long; 10 x 25% = 2.5 inches; 10 x 33% = 3.3 (or ju of 33/8 inches). Most model airplane designs use the distance between 25-percent MAC and 33-percent MAC as the model's CG range. I g my word on this: if you balance your model anywhere between the 25- and 33-percent MAC balance points, your model will fly safely.

FINE-TUNING THE CG

To really zero in on a model's ideal neutral CG, you need a few test flights. A model can tell us where its CG is by how it reacts in flight. Fo basic trainer and other high-wing, high-lift designs, establish a level flight path, and trim it to fly hands-off at about ½ throttle. If excessiv trim is needed to keep the nose level, the CG is too far forward. If the model requires a lot of down-trim, the CG is too far back. Move the pack around to fine-tune the balance point. Once the model has been properly set up and the trims set, fly it straight and level again and what happens when you adjust the throttle. If the model is properly trimmed and balanced, adding power from the ½-throttle setting wi it to climb gently. Reducing power to less than ½ throttle will make it descend.



To find the MAC of a swept wing panel, you do the same as for a tapered wing panel. Notice that the MAC is still the same distance from the root rib, but now, its fore/aft position relative to the root rib has changed. The measurement lines for balancing have shifted aft.

For models that are neutrally stable, set the power to ½ throttle and trim for straight and level flight. Now enter a 30-percent nose- dow descent (a shallow dive), and watch for the speed to increase. Now let go of the stick and see what happens. If the model continues the angle or gradually starts to recover, the CG is very close to where it should be. If the model pulls up quickly, its CG is too far forward (it's heavy). If the model dives at a steeper angle, the CG is too far aft (tail-heavy.) These reactions are caused by the amount of elevator trim was used to establish the original straight and level flight path. A nose-heavy plane requires additional downforce at the tail to fly straigh established airspeed (½ throttle). In the dive, the additional airspeed increases the tail's downforce and the model's nose is forced upwa opposite hap- pens with a tail-heavy plane, and when the airspeed increases, the increased tail up-force pushes the nose down.

The best insurance policy for any model airplane is to have it balanced as close as possible to its correct CG before flying. Feeling what t model tells you when test-flown will help you fine-tune its balance.

Knowing where your new model should be balanced is the first step to flying it successfully. Understanding these basic forces and knowi to adjust your model's CG position allows you to fine- tune how it reacts to control inputs. Tail heaviness increases maneuverability, whil heaviness increases stability. A nose-heavy airplane, however, tends to land at a faster speed, while extremely tail-heavy airplanes can b uncontrollable. Some basic calculations before that first flight will help keep your model whole. Get the balance right!

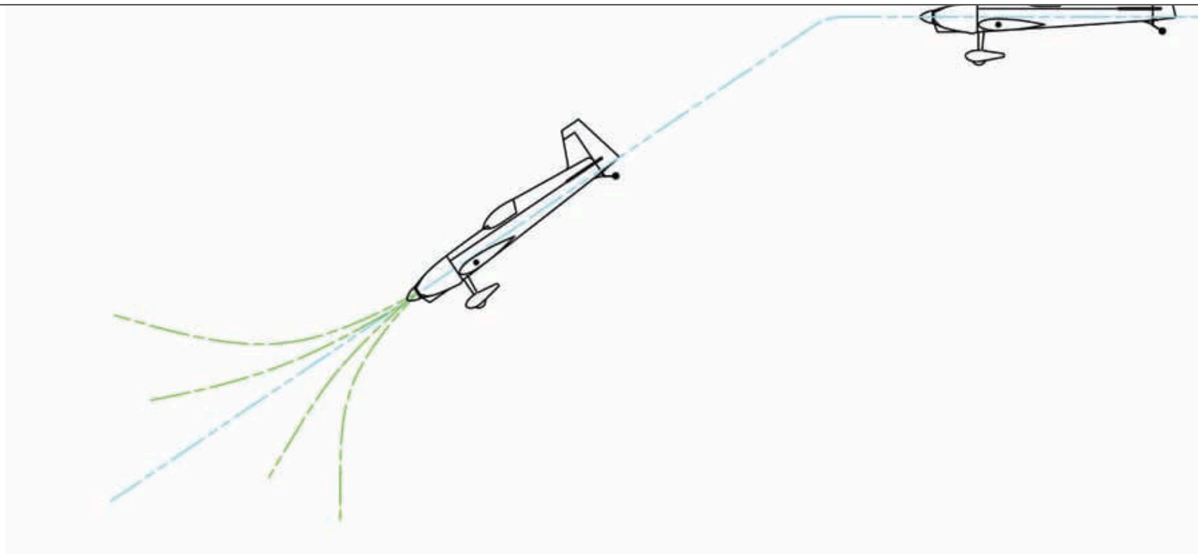
The Dive Test

An excellent way to check your model's CG is to use the dive test method. Although it might seem backward, the test works very well.

Fly your plane at 1/2 throttle, and adjust the elevator trim until it can maintain hands off level flight. Check this by making several passes changing the throttle setting. You should be flying at an altitude of 100 to 150 feet. When the plane is nearing center stage, gently push i 30-degree dive, and hold it until the air speed has increased noticeably. At this point, take your hand off the stick and observe what happ

If the plane pulls up sharply, it's very nose-heavy. If it continues in the dive or pulls up slightly, its CG is just right. If it tries to tuck under, heavy. This happens because the increase in speed amplifies the trim corrections. If the model was carrying some up-trim to correct a n heavy condition, the increased dive speed makes the model pull up and vice versa.

Extra advantages come with having a correct CG location. You won't need as much elevator throw, and that will mean less control drag. will be virtually no need for down thrust, which is an inept attempt to "fix" the tendency of an over stabilized aircraft to nose up as powe increased.



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Photos by David Hart (CapturedFromtheHart.com)

3 COMMENTS

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