

Weight & Balance

Have you ever picked up a shovel full of dirt and felt the weight of all that dirt way out on the end of the handle. It gets heavy real fast and the further the weight is from your hands the heavier it gets. Same thing happens to an airplane. The weight of fuel, people, baggage it all adds up and unless you pay close attention to the total weight and WHERE it's located you could have trouble controlling the airplane.

An airplane has to be balanced within limits in order to safely fly. Some leeway is designed into the plane, but each item of weight counts and where it's located is important. All airplanes have a point on the plane from where loading measurements are made. That point is called the "Datum" and on single engine planes it's usually the firewall between the engine and the passenger compartment. The Pilot Operating Handbook (or, Owner's Manual on older planes) specifies where the Datum line is at. The important part is to know how far away from the Datum a particular weight is to be placed. The distance from the datum determines the effect the weight has on the controllability of the plane.

There's actually a formula to calculate this effect.

Weight of the item - multiplied by Inches from the Datum line - equals the "Moment". Why the word Moment, I don't know, but probably has something to do with standard physics terminology. Inches from the Datum is called the "Arm"

Weight X Arm = Moment

The trick is to calculate the total weight of the plane and the total Moments of all loads to see if everything is within safe operating limits. The distance from the Datum can be either in front of (fore), or behind (aft), of the Datum line. If in front of the Datum line the Moments for a particular load is subtracted from the total, otherwise the Moments are added. The weight is always added to the gross weight total.

Once the total Moments and total gross weight is determined the next step is to see if the weight & loading is within the allowed limits for the plane by applying the total weight and total moments to Center of Gravity (CG) envelope.

When applied to the CG envelop the Gross weight vs total Moments MUST fall within the CG envelop. If it falls outside the envelope the plane will be unstable and bad things may happen. Where the CG is located has an effect on stall speeds and in general how the plane "feels" during flight. Being over gross, or having too much weight in the wrong place is NOT how you want to start your day. The CG envelope for Blue Bird shows two envelopes, one inside the other. The inside one is labeled "Utility". If your loading falls inside the Utility category that's a good thing. That means the loading you have allows for a more aggressive operation of the plane. Some training maneuvers require the loading to be in the Utility category, such as spins and accelerated stalls.

The Owner's Manuals for our two planes describe slightly different methods for calculating the "Empty Weight" of each plane. For the C-150, the empty weight includes the unusable fuel, PLUS a full oil tank. For the C-172 it appears they weighed the plane full of fuel and oil, then calculated the empty weight as if they had drained all the fuel and oil they could leaving the unusable fuel and inaccessible oil,

so the weight of usable oil has to be included in the calculations. The provided sample works sheets handle the different approaches.

Formatting web pages can be a challenge when mixing data from different applications such as Word, Excel, pictures from the Owner's manual, etc., so you may have to scroll down a bit to see the CG envelopes. If you have trouble reading the CG envelope for Blue Bird try opening the owner's manual, locate the Weight & Balance section that version may be a little clearer.

For sample Weight & Balance worksheets with CG envelopes access the main menu tabs for the C-150 (Tweety), or C-172 (Blue Bird), then click on "Weight & Balance".