Testing>Weight and balance

Objectives of this task:

To calculate the *Empty Weight* and the balance point or *Centre of Gravity* of the aircraft.
The *Empty Weight Trim Index* is calculated from these values and then various loading scenarios are be tested to see if any rebalancing of the aircraft is required. Finally all values are entered into the *Aircraft Empty Weight Record* in Section 6.2 of the Owners Manual.

Equipment required:

3 bathroom scales capable of weighing up to 150Kg
Plumb bob and string line, set square
Builders type spirit level
Chalk and a builders chalk line to mark the reference positions onto the hangar floor

Prepare the equipment

Before you do anything else, check your scales for accuracy: use some objects of a known weight, such as a few 20Kg bags of cement to see if your scales are reading correctly at around the 100Kg range of the scale.
If there is a problem then either adjust the scale or, if this is not possible, note how much the scale over/under reads and apply this as a correction to the weight displayed.

Prepare the aircraft

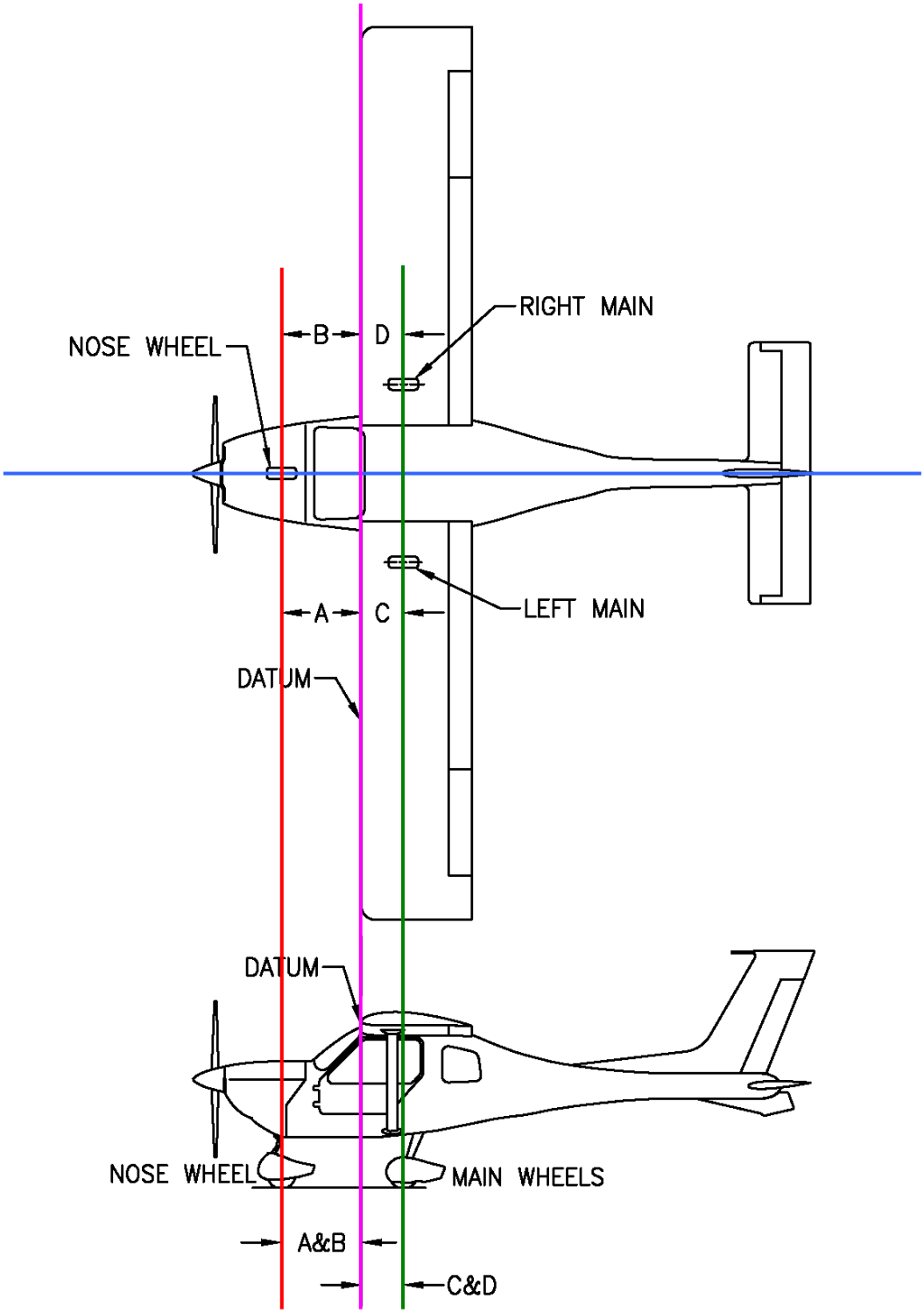
Remove all surplus items from the cockpit: tools, clothing, etc. and clean the interior of the aircraft with a vacuum cleaner. Clean the exterior of the aircraft: remove all dust and dirt with a damp cloth. Check that the engine oil is full to the bottom of the hatched marking on the dipstick. Turn the fuel tap on the console to the OFF position (lever facing up).
Fill the header tank with fuel but leave zero fuel remaining in the wing tanks.
The aircraft should contain everything required for flight except fuel in the wing tanks.

Reference points

In this task you will be measuring the horizontal distances from the *Datum*, which is the leading edge of the wing, to the main wheel axles and the front wheel axle.
Each reference point will be marked onto the hangar floor and then measured.

Mark and measure

Refer to the drawing on the next page for colour-coded details of the line markings.
Use a chalk line to mark 2 lines at least as long as the aircraft on the hangar floor in a right angle cross. Roll the aircraft directly along one line (coloured **blue** in the drawing) until the main wheels are directly over the second line (coloured **green** in the drawing).
The main wheel axles must be ***directly*** over the second (**green**) line: use a square or a plumb line from the axle bolt centres in the main wheel spats to check this and move the aircraft as required. Leave the brakes off and chock the main wheels when the position is correct.
Mark the *Datum* line (coloured **purple** in the drawing) on the floor by means of a plumb line hung from the leading edge of each wing, using a point about 300mm outboard of each main wheel. Join both *Datum* line marks and mark a line across the floor with your chalk line.



Mark a point on the floor directly under the centre of the front axle bolt on each side: use a square or a plumb line from the axle bolts in the front wheel spat to check this.

Now measure the distance from each side of the front axle (the **red** line above) to the *Datum* line: these are distances **A** and **B**. add them both together and divide by 2 to get the average distance – this will compensate if the front wheel is not set exactly straight ahead. Enter the distance as a negative value in the *Distance to Datum* column on the chart on the next page.

Measure the distance from the **left** main wheel axle to the *Datum* line and enter the value at distance **C** in the chart on the next page. Do the same for the **right** main wheel (distance **D**).

Weigh the aircraft

The weighing part of this procedure should be conducted in a closed hangar with a level floor. Because the aircraft is very light any wind will adversely affect the weights, so a closed building, without any doors being opened during the procedure, is required.
Place a set of scales under each wheel and level the aircraft: use a builders level across the lower door sills to check for lateral level, and along each lower door sill to check for longitudinal level. Pack under wheels as required to level the aircraft.
Record the weight of each wheel under the "Weight" column in the chart below.
Note: if you have access to only 1 set of scales you may weigh each wheel individually, however you will need to pack under the other wheels to level the aircraft before each weight is recorded.

Calculate the Empty Weight and Centre of Gravity

Sum all of the items in the *Weight* column and put the total at the bottom of the column.
All distances aft of the *Datum* are considered positive and all distances forward of the *Datum* are considered negative in the calculation that we are about to do in this step.
Calculate the *Moment* of each wheel: starting with the nose wheel, multiply the *Weight* by the *Distance to Datum* and record the result in the *Moment* column. Note that the *Distance to Datum* value for the nose wheel will be a negative value and the result will also be negative.
Multiply the *Weight* by the *Distance to Datum* and record the result in the *Moment* column for each main wheel. These results will both be positive values.
Sum all of the items in the *Moment* column and put the total at the bottom of the column.
Divide the total *Moment* by the total *Weight* and record the result in the red box at the bottom of the chart – this is the distance aft of the leading edge where the empty aircraft will balance and is referred to as the ***Empty Aircraft Arm***.

Item	Weight (kg)	X	Distance to Datum (mm)	=	Moment (kg/mm)
NOSE WHEEL			(A+B)/2 -		-
Left main wheel			(C) +		+
Right main wheel			(D) +		+
Column totals:			Moment / Weight		
	Empty Aircraft Arm:				mm aft of *Datum*

Calculate the Empty Weight Trim Index

MULTIPLY THE *EMPTY AIRCRAFT WEIGHT* BY THE *EMPTY AIRCRAFT ARM* AND DIVIDE THE RESULT BY 1000 TO ARRIVE AT THE *EMPTY WEIGHT TRIM INDEX*.

This value can be used in the *Load and Balance Worksheets* in Section 6 of the Owners Manual.

Examples of calculation

Below is an example calculation showing typical values:

Item	Weight (kg)	X	Distance to Datum (mm)	=	Moment (kg/mm)
NOSE WHEEL	75		- 780		- 58,500
Left main wheel	108		+ 475		+ 51,300
Right main wheel	108		+ 475		+ 51,300
Column totals:	291		Moment / Weight		44,100
	Empty Aircraft Arm		151.55		mm aft of *Datum*

Empty Weight Trim Index: [(291 x 151.55) / 1000] = **44.1**.

Rebalancing the aircraft

You must now use the *Load and Balance Worksheets* in Section 6 of the Owners Manual to test all of the likely loading scenarios for your intended operations and see if any fall outside of the envelope.

For factory built aircraft we are required to use the CASA-approved standard passenger weight (currently 86kg) to calculate loadings, but as you are the builder you may choose to use the actual weights of yourself and your regular passenger(s) along with items that you intend to carry with you, such as tie downs, toolkit, suitcases, camping equipment and so on.

If it seems possible that an intended loading could exceed, for example, the forward limit, then you would need to consider adding some ballast to the rear of the aircraft.

If any rear ballast is required the preferred method is to add it in the form of lead shot mixed with resin to the ventral fin. (Note: It is unusual to need forward ballast – if there is an intended loading that would require forward ballast it will usually be very close to MTOW anyway and should very probably be avoided altogether.)

Assuming that rear ballast is required you would measure the arm of the ballast station/ location from the *Datum* and calculate the weight of ballast required, adjust the calculations to obtain a revised *Empty Aircraft Weight*, *Empty Aircraft Arm* and *Empty Weight Trim Index* and then retest all of the likely loading scenarios for your intended operations and see if any still fall outside of the envelope.

Once you are satisfied that the majority of the likely loading scenarios for your intended operations will fall inside of the envelope, you may physically add the ballast and repeat the weighing procedure and then record the revised values in the *Aircraft Empty Weight Record* in Section 6.2 of the Owners Manual.

This completes the *Testing>Weight and balance* task.