

Weight and Balance



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Introduction to Terms

- Datum
- Arm
- Moment
- Station
- CG
- Envelope
- Basic Empty Weight

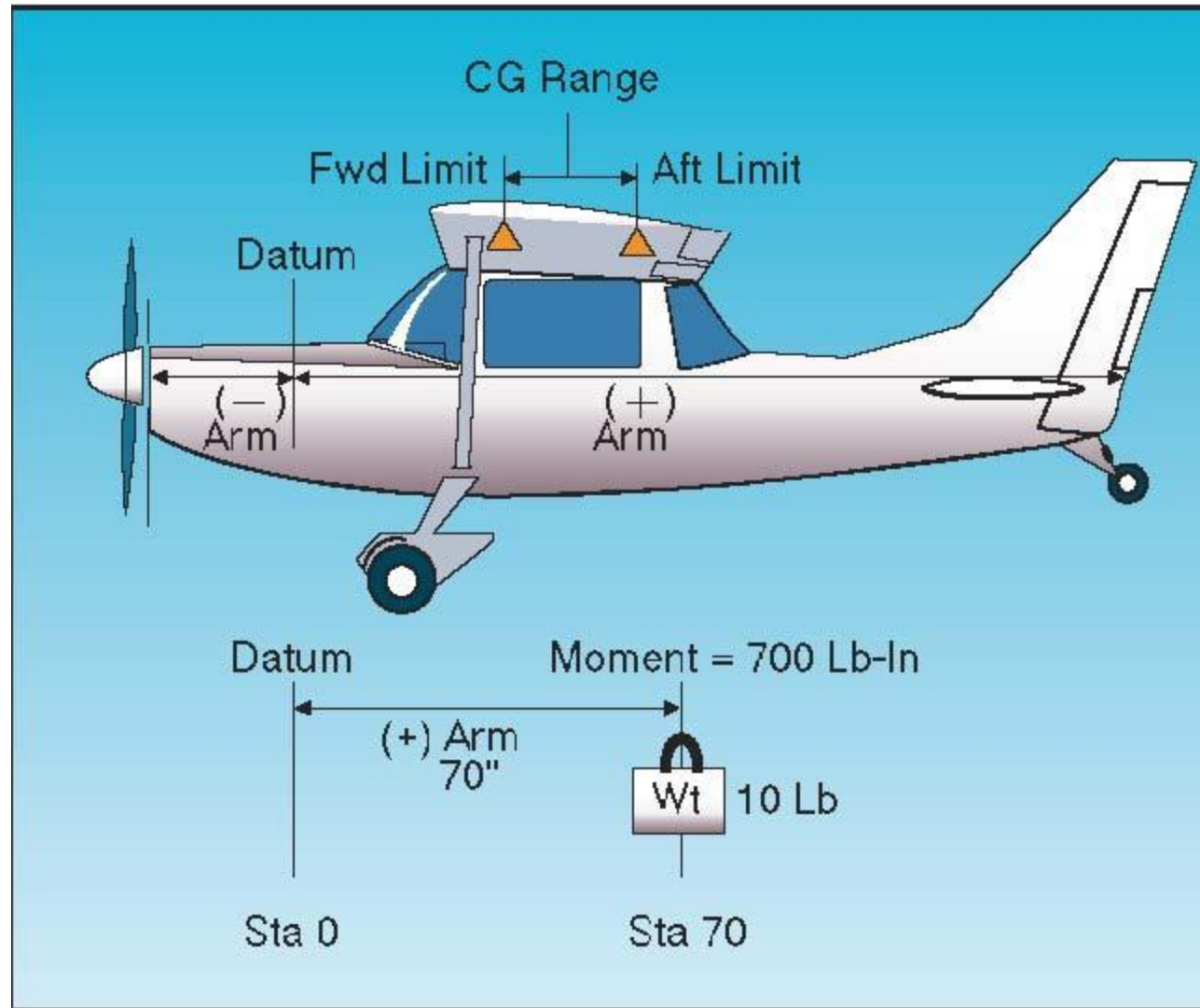


Figure 8-2. Weight and balance illustrated.

Terms

- Datum
 - Reference for All Weight and Balance Measurements
 - Aircraft Specific
- Arm
 - Length from the Datum
 - Can be Positive or Negative
- Moment
 - Product of An Item's Weight x Arm
 - Watch Units

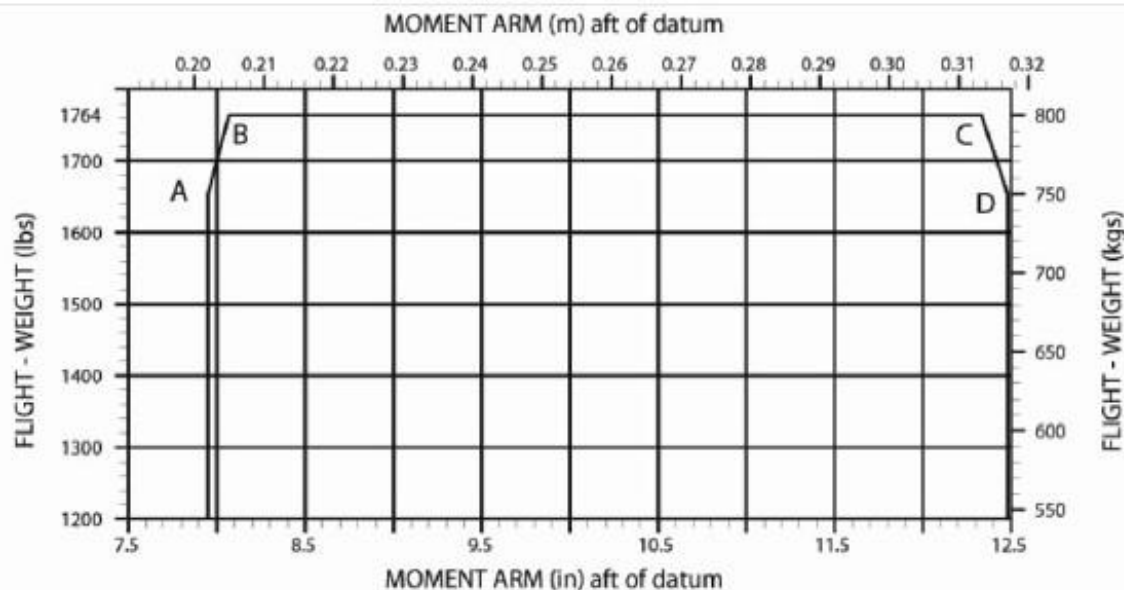
Terms (cont.)

- Station
 - General Location in Aircraft
 - E.g., Front Seats, Baggage Compartment, Rear Seat, Fuel Tank
- CG – Center of Gravity
 - Distance from Datum Line
 - $CG = (\text{Sum of All Moments}) / \text{Total Weight}$

Terms (cont.)

Envelope Has Range of CG and Weight Displayed as Graph

This is Example of a Diamond (DA20-C1)



Points	Gross Weight		Arm (aft of datum)	
	(lbs)	(kgs)	(in)	(m)
A	1653	750	7.95	.202
B	1764	800	8.07	.205
C	1764	800	12.16	.309
D	1653	750	12.48	.317

Terms (cont.)

- Basic Empty Weight
 - Weight of Airplane
 - Full Operating Fluids (Oil, Hydraulic, etc. but not Usable Fuel)
 - Unusable Fuel

Some Examples

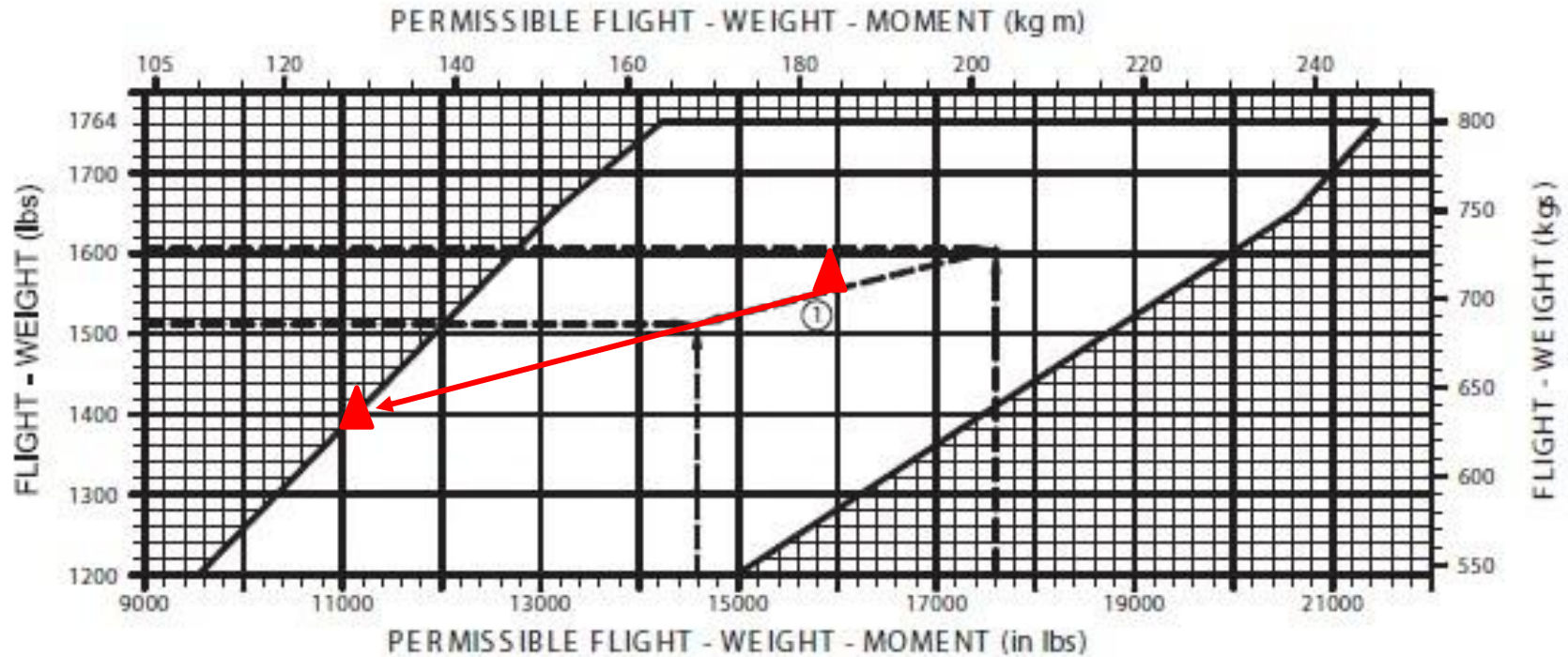
- Compute Moments and CG
 - Example 1
 - Arm = +34"
 - Weight = 20 lb
 - Moment = +34" x 20 lb = 680 in-lbs
 - Example 2
 - Arm = -20"
 - Weight = 20 lb
 - Moment = -20" x 20 lb = -400 in-lbs
 - Example 3 – What is CG of the Above Two Moments
 - $CG = (\text{Moment 1} + \text{Moment 2}) / \text{Total Weight}$
 - $CG = [680 + (-400)] / (20+20) = 280/40 = +7"$

Example – N141BB

1. Start With Empty Weight
2. Obtain This from Weight and Balance
3. Compute Passengers and Load Stations
4. Add Fuel

	Calculation of the Load Limits	DA20-C1 (EXAMPLE)		YOUR DA20-C1	
		Weight [lbs] (Weight [kg])	Moment [in.lbs] ([kgm])	Weight [lbs] (Weight [kg])	Moment [in.lbs] ([kgm])
1.	Empty Weight (use the data for your airplane recorded in the equipment list, including unusable fuel and lubricant).	1153 (523)	12562 (144.740)	1186 lbs	9,855.66 in-lbs
2.	Pilot and Passenger: Lever Arm: 0.143 m (5.63 in)	359 (163)	2021 (23.286)	220 lbs	1,238.6 in-lbs
3.	Baggage: Max. Wt. 44 lbs (20 kg) Lever Arm: 0.824 m (32.44 in)	-- (--)	-- (--)		
4.	Baggage Compartment Extension: Max. Wt. 44 lbs (20 kg) Lever Arm: 1.575 m (62.0 in)	-- (--)	-- (--)		
5.	*Combined Baggage Max. Wt. 44 lbs (20 kg) Lever Arm: 1.20 m (47.22 in)	-- (--)	-- (--)		
6.	Total Weight and Total Moment with empty fuel tank (sum of 1. - 3.)	1512 (686)	14583 (168.026)	1406 lbs	11,094.26 in-lbs
7.	Usable Fuel Load (6.01 lbs. per US gal./0.72 kg per liter) Lever Arm (32.44 in) (0.824 m)	93 (42)	3017 (34.762)	144.24 lbs	4,679.56 in-lbs
8.	Total Weight and Total Moment, taking fuel into account (sum of 6. and 7.)	1605 (728)	17600 (202.788)	1550.24 lbs	15,773.82 in-lbs
9.	Find the values for the total weight (1512 lbs and 1605 lbs) and the total moment (14583 in lbs and 17600 in. lbs) in the center of gravity diagram. Since they are within the limitation range, the loading is permissible.				

Example (cont.)

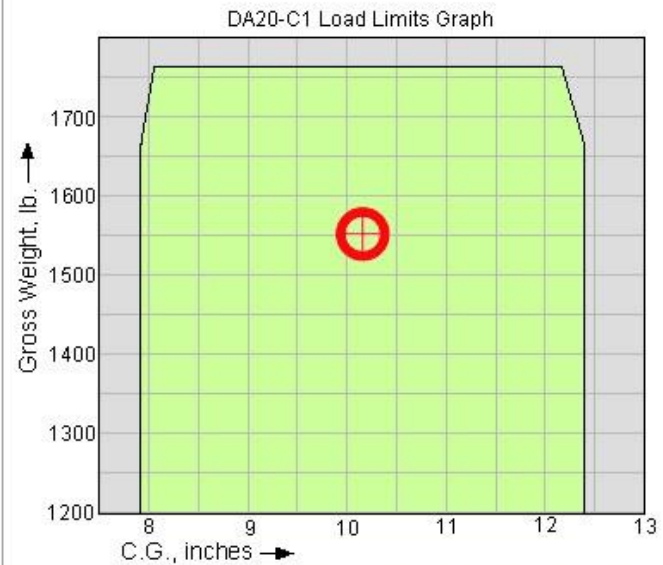


Note as Fuel Burns Off – You Reduce Weight But Come Close to Exceeding the Permissible Flight Envelope

What is the CG at Beginning of Flight and After Fuel is Burned Off?

N141BB Diamond DA20-C1 Weight and Balance Calculator

Form default data is for N141BB. ONLY!	Weight (lbs)	Arm (inches)	Moment (in-lb)
Basic Empty Weight	<input type="text" value="1186"/>	<input type="text" value="8.31"/>	<input type="text" value="9856"/>
Front Seat L & R	<input type="text" value="220"/> <input type="text" value="0"/>	<input type="text" value="5.63"/>	<input type="text" value="1239"/>
Fuel (24 gal useable)	Gallons: <input type="text" value="24"/> Fuel Wt: <input type="text" value="144"/> lbs.	<input type="text" value="32.44"/>	<input type="text" value="4671"/>
Baggage (44 lb max)	<input type="text" value="0"/>	<input type="text" value="32.44"/>	<input type="text" value="0"/>
<input type="button" value="Calculate"/> <input type="button" value="Reset"/>			
Gross Weight (1764 lb max):	<input type="text" value="1550"/>		<input type="text" value="15766"/>
Loaded Center of Gravity:		<input type="text" value="10.17"/>	
Maneuvering speed, Va (kts):	<input type="text" value="100"/>	<=(decr. with decr. wt.)	



This active chart requires a CSS compliant browser.
CSS scheme for active graph from [C172 G-BSEP W & B Calculator](#).

**This Uses the Online Weight and Balance
on the Texas State Aviation Web Site**

**Why is the Shape of this Envelope
Different than that of the Previous Page?**

Calculated Gross Weight and C.G. point must lie within envelope limits per the *Airplane Flight Manual*

Weight Shift Formula

Weight Moved/Total Weight = CG Change/Distance Between Station CGs

- Sometimes CG is Out of Limits But Weight is Acceptable
- It May be Possible to Shift an Item from One Station to Another
- Let's Say CG is 1" to Far Aft And You Have 80 lb of Baggage That Can Be Brought Forward to a Rear Seat – the Distance Between Rear Seat Station and Rear Baggage is -20 "
- Total Weight = 1575 lbs

Weight Shift Formula (cont.)

- $80/1575 = \text{CG Movement}/(-20)$, or
- $\text{CG Movement} = (-20) * 80 / 1575 = -1.01''$

Summary



Watch your Weight



And your Balance