

Weight and Balance



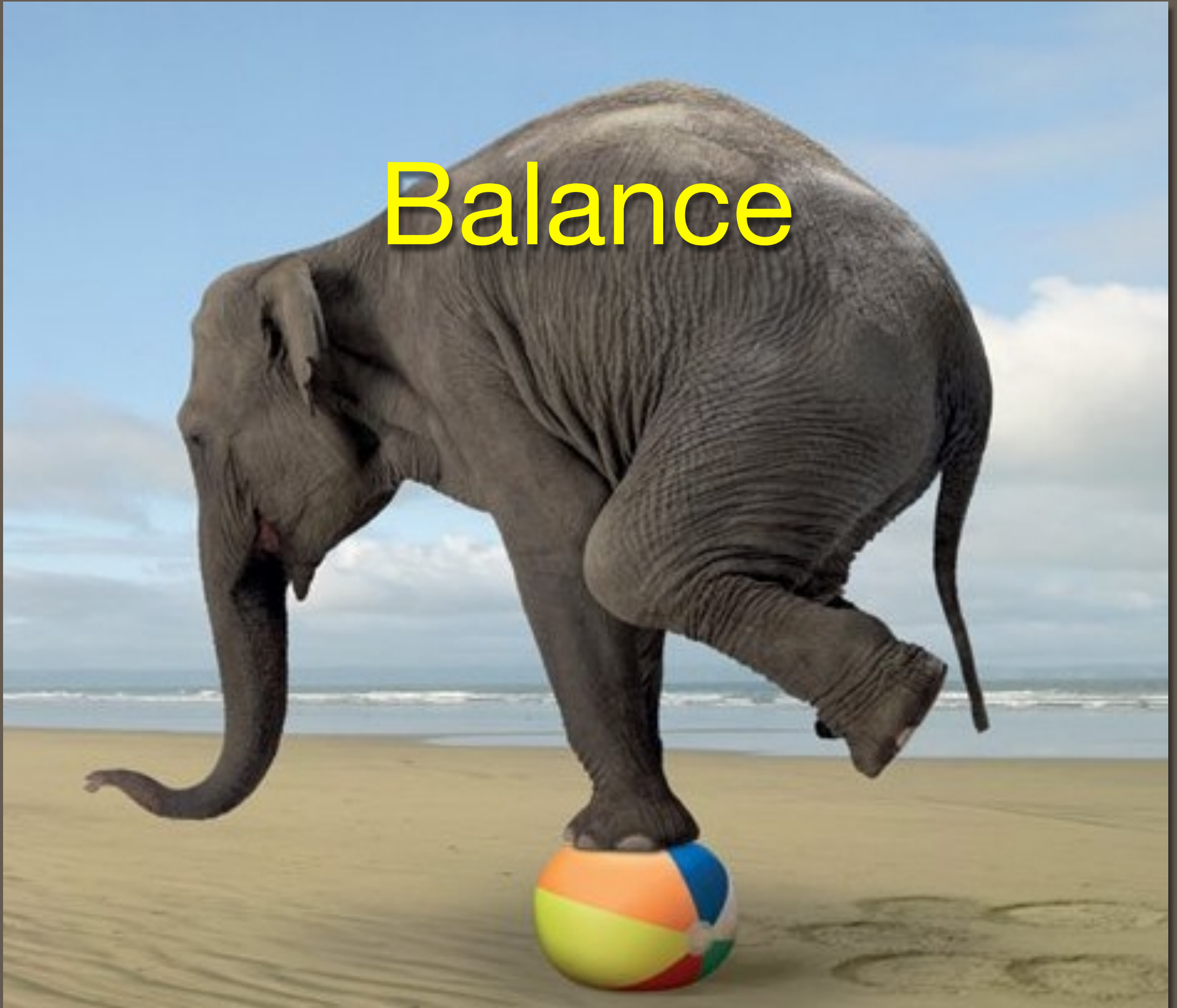
Weight Effects

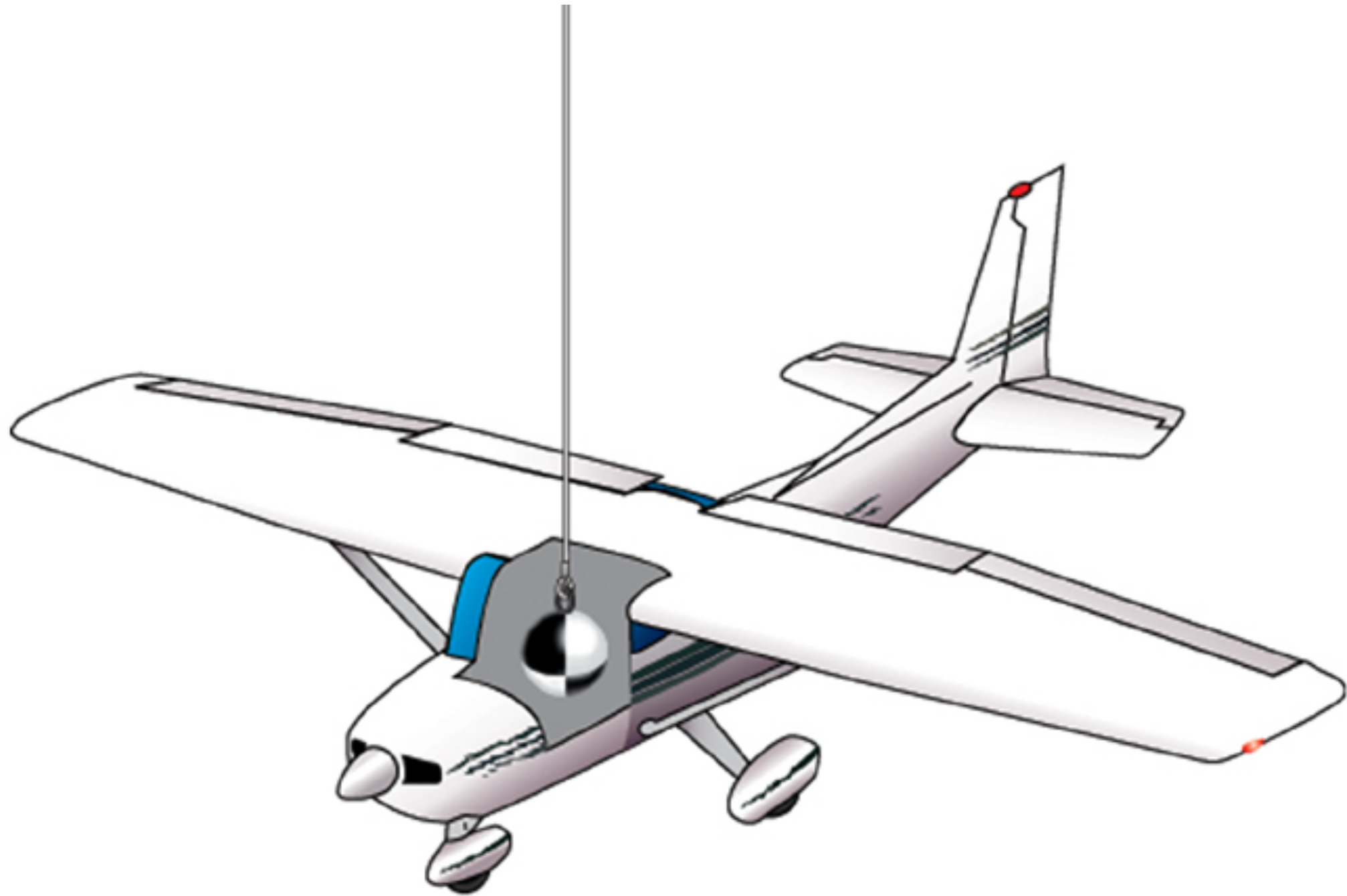
- Takeoff roll and takeoff speed
- Angle and rate of climb
- Cruise speed and range
- Stall speed
- Landing speed and ground roll

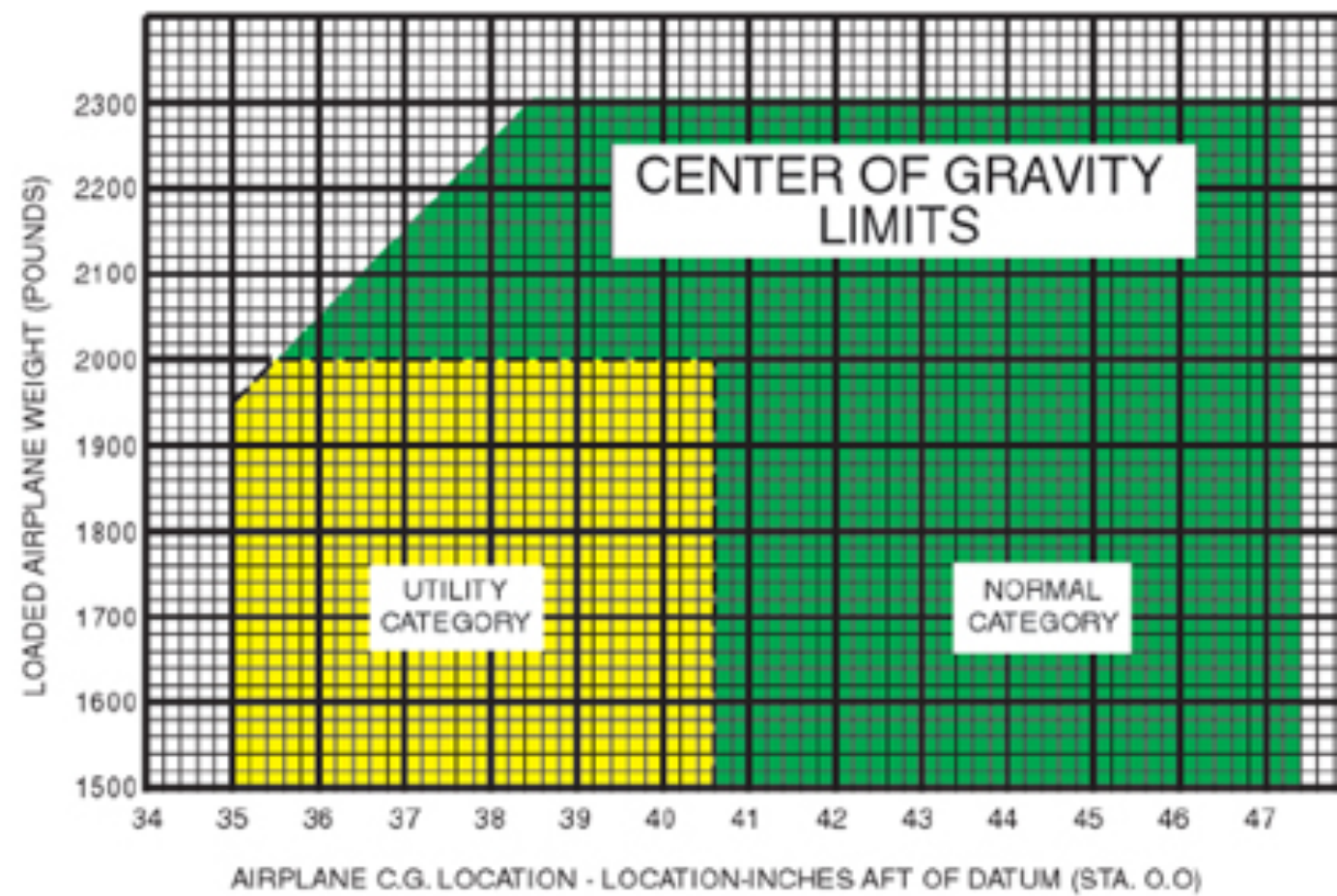
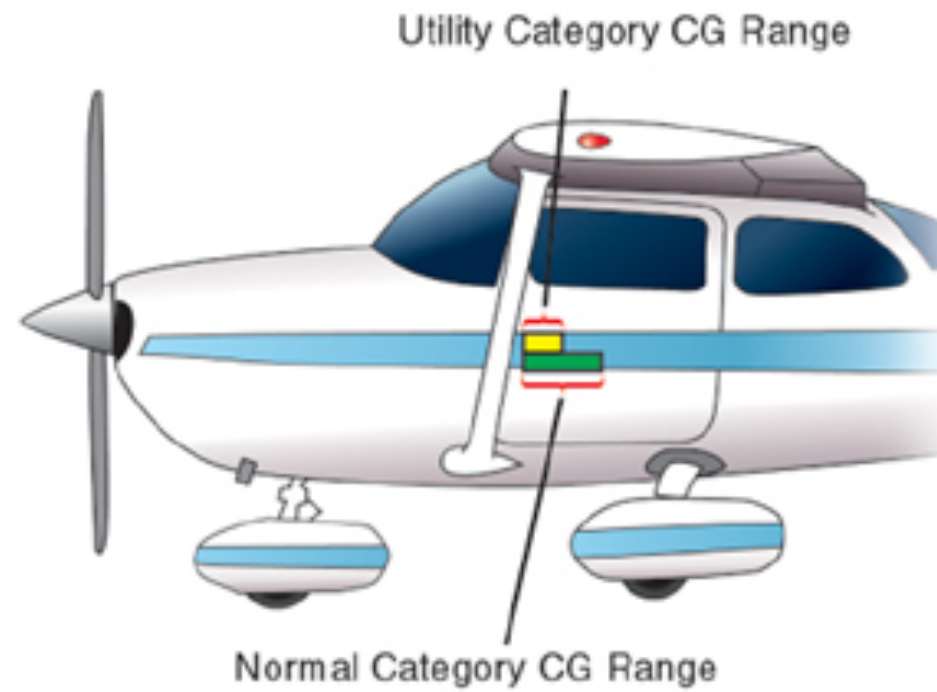
Exceeding Weight Limits

- Decrease Aircraft Performance
- Risks Structural Damage
- Loss of Aircraft Control

Balance







Exceeding Forward CG Limit

- Reduces control/stability during landing
- Higher stall speeds
- Higher control forces
- Reduce ability to flare in landing
- Excessive loads on nose wheel

Exceeding Aft CG Limit

- Reduces longitudinal stability
- Lighter control forces
- Difficulty recovering from stalls/spins

Terms

- Basic Empty Weight (BEW)
- Unusable/Usable Fuel
- Payload

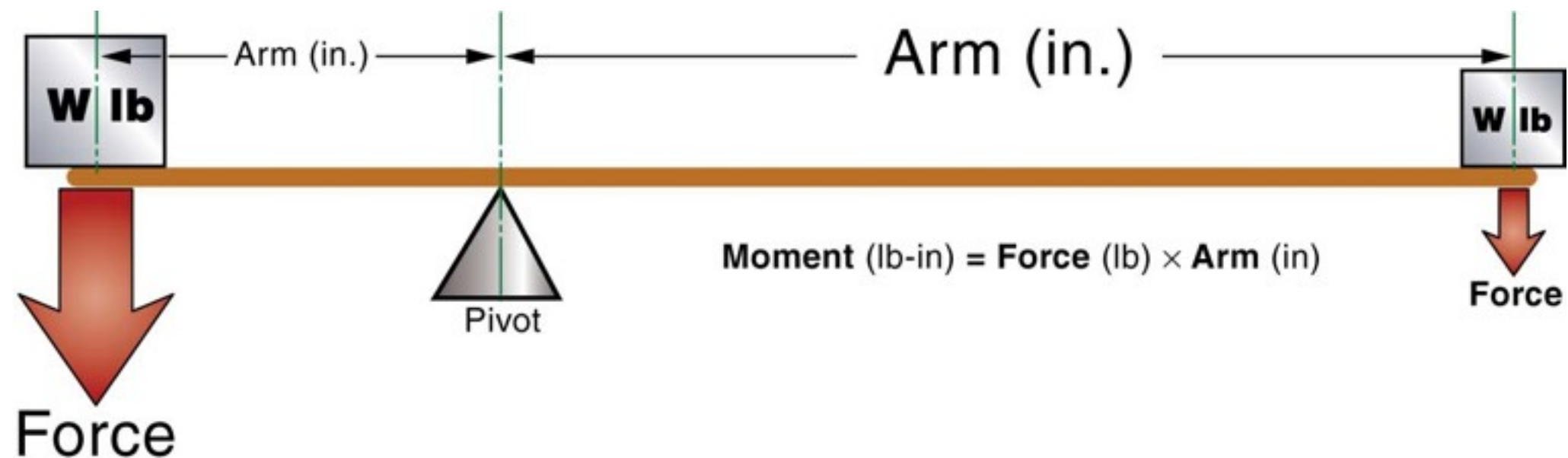
Terms

- Ramp Weight = BEW + Payload + Usable Fuel
- Zero Fuel Weight = Ramp Weight - Usable Fuel
- Useful Load = Payload + Usable Fuel
- Landing Weight = Ramp Weight - Fuel Burn off

Limitations

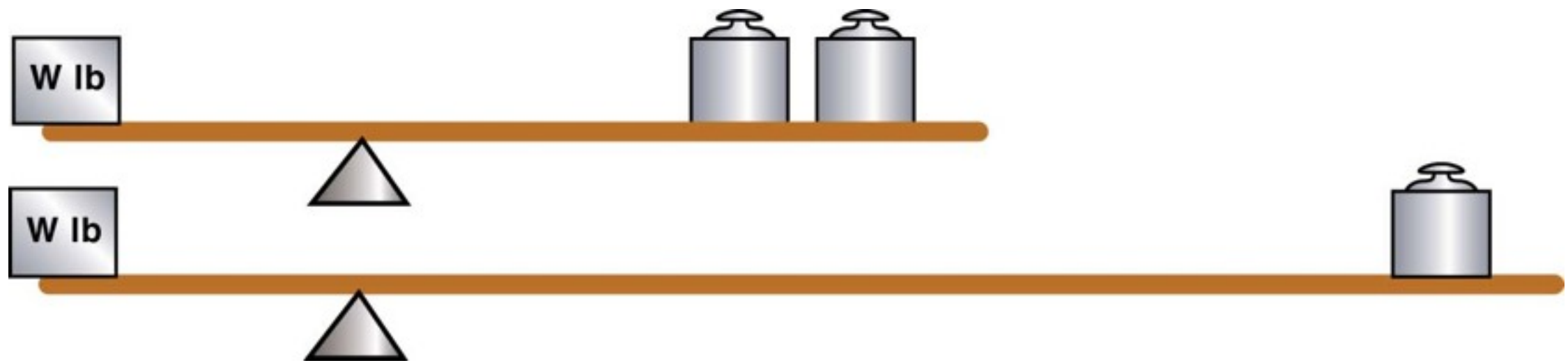
- Maximum Ramp Weight
- Maximum Takeoff Weight
- Maximum Landing Weight

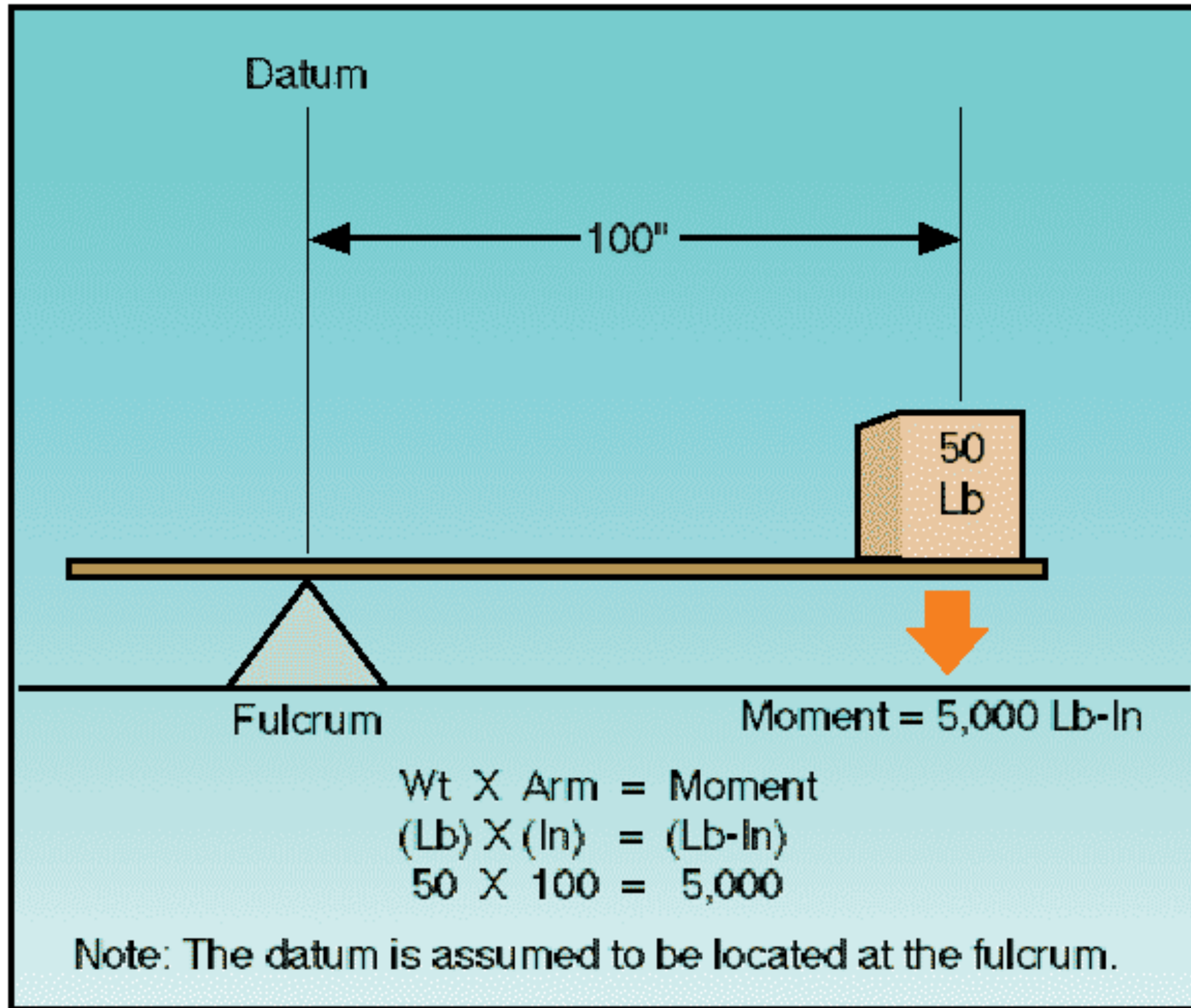
Weight and Balance

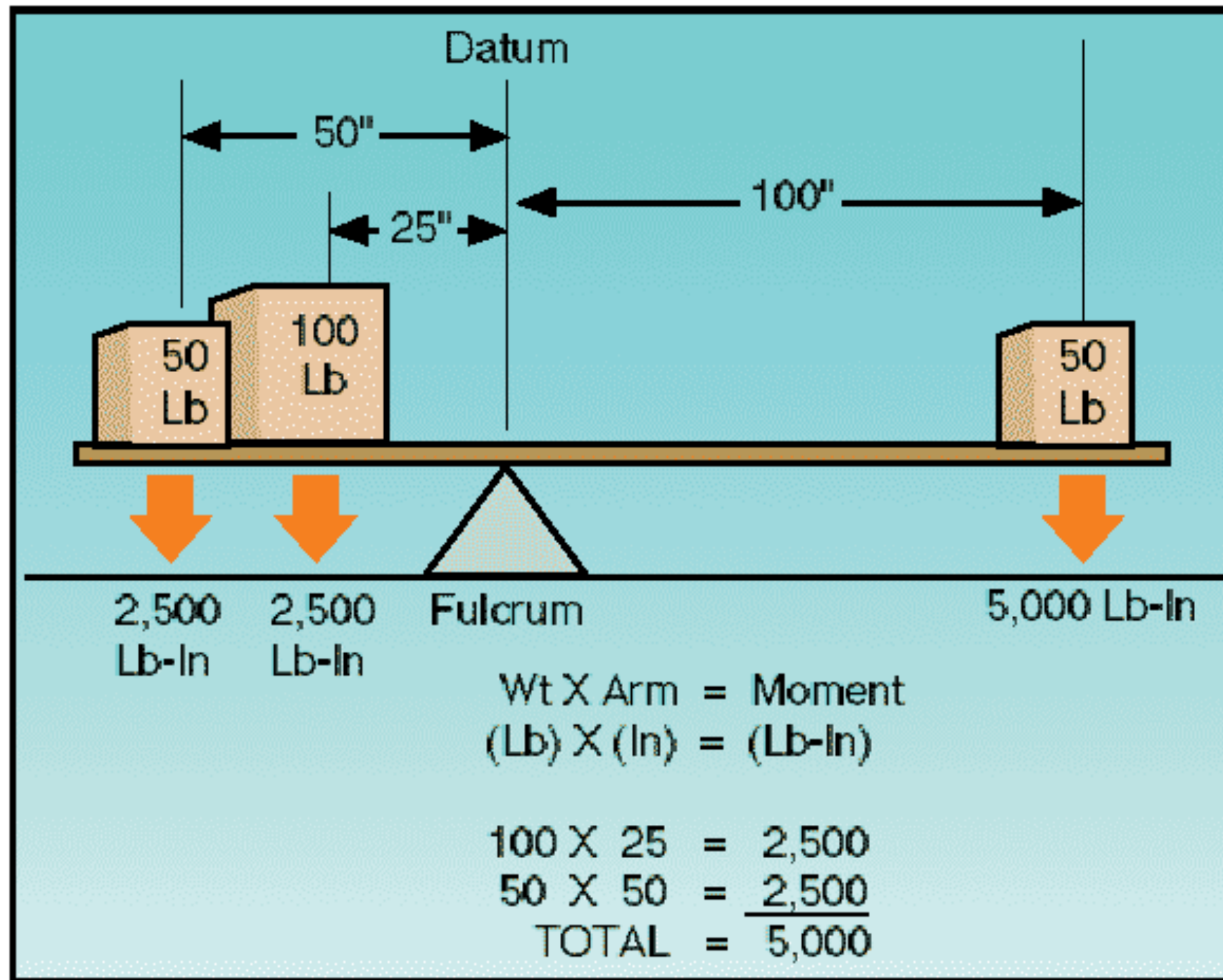


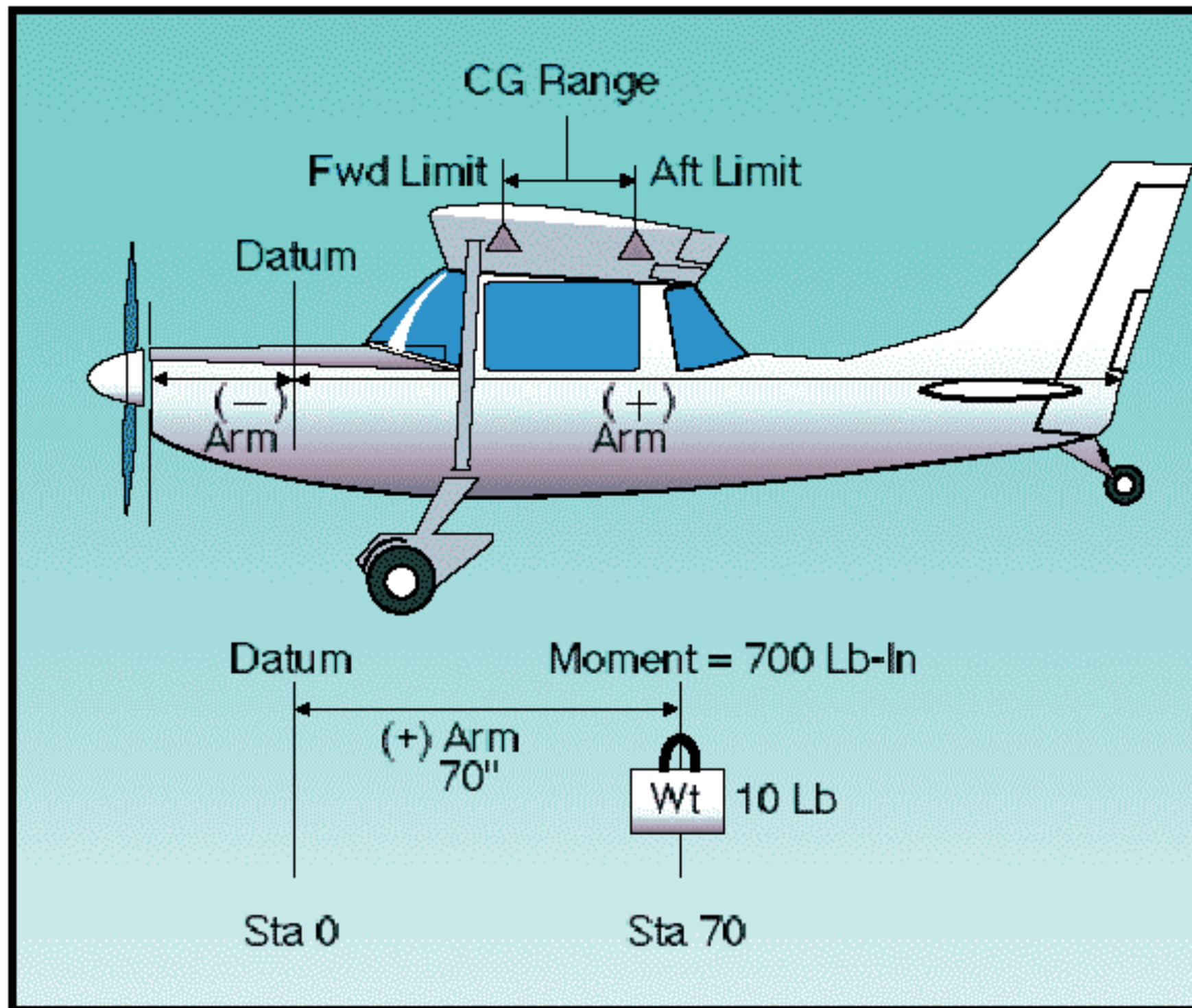
Balanced when moments are equal

Weight and Balance









Reference Datum

The datum is 66.25 inches ahead of the wing's leading edge.



The datum is at the front face of the firewall.



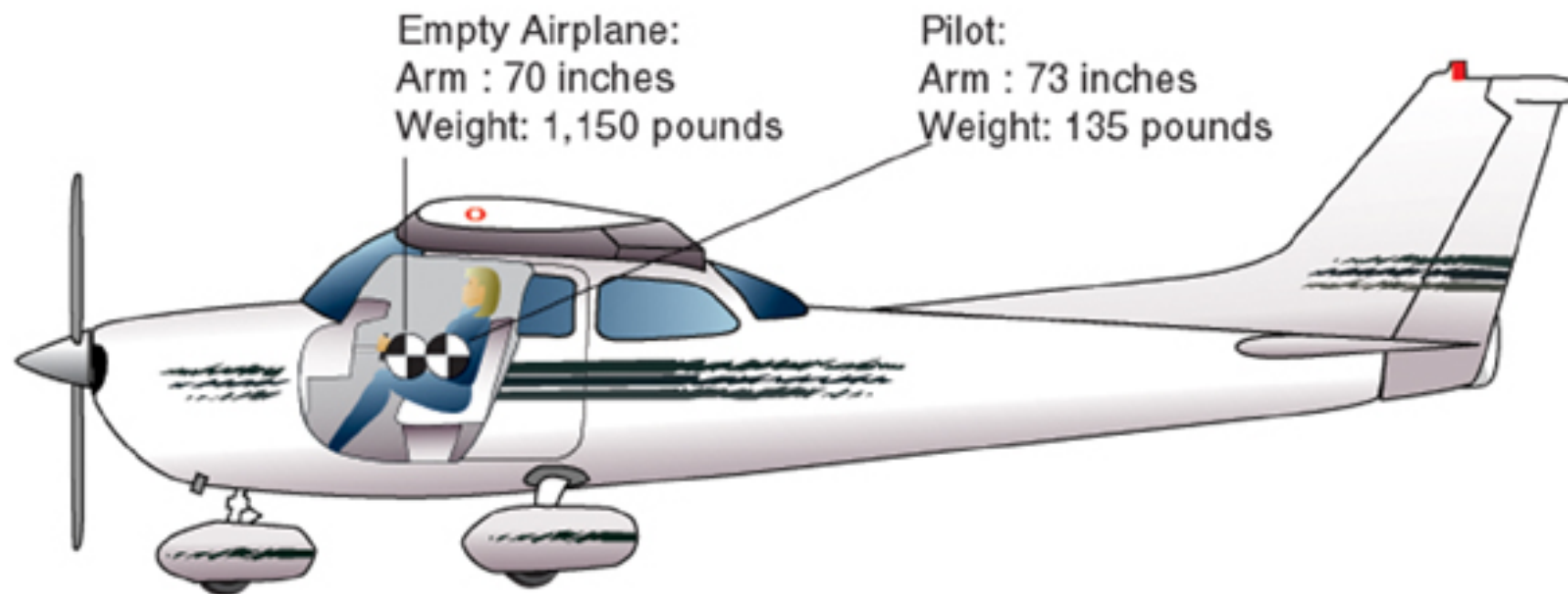
The datum is 109.7 inches ahead of the center of the main gear.



Basic Weight/Moment



$$\text{CG} = \text{Total Moment} / \text{Total Weight}$$



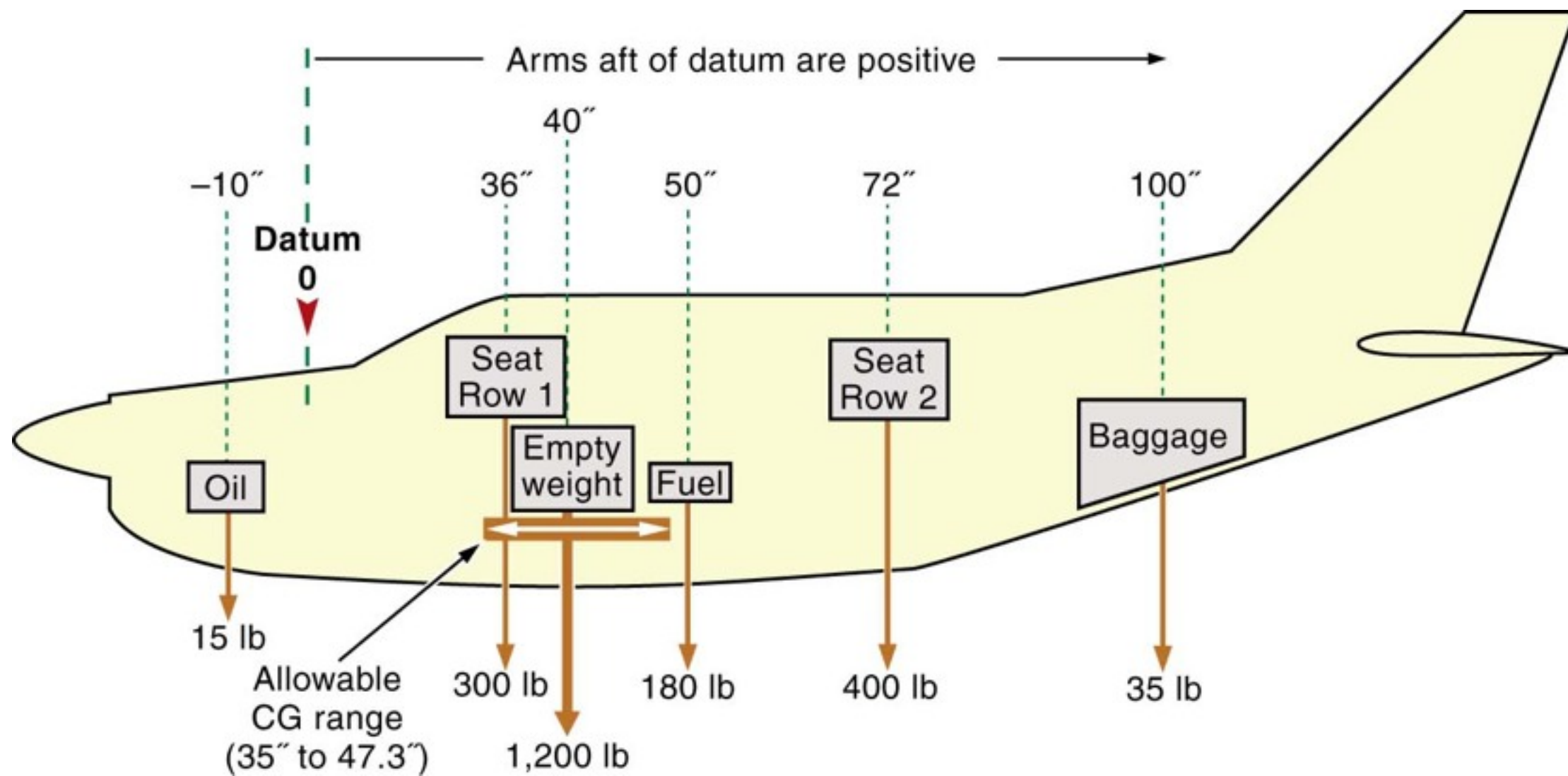
	Weight		Arm		Moment
Empty Airplane	1,150 pounds	X	70 inches	=	80,500 pound - inches
Pilot	135 pounds	X	73 inches	=	9,855 pound - inches
Total	1,285 pounds				90,355 pound - inches

$$\frac{\text{Total Moment}}{\text{Total Weight}} = \text{CG Arm} \quad \frac{90,355 \text{ pound-inches}}{1,285 \text{ pounds}} = 70.3 \text{ inches}$$

	Weight (lb)	Arm (in)	Moment (lb-in)
	STEP 2 6 + 3	× 10 = 60 + 120	STEP 2 60 + 120
Total	9	STEP 3 $\frac{180}{9} = 20$	STEP 3 180

To find the CG position:

1. calculate the individual moments;
2. calculate the total weight and the total moment; and
3. find the CG arm: $\frac{\text{total moment}}{\text{total weight}}$



Item	Weight (lb)	Arm (in)	Moment (lb-in)
Empty weight	1200	40	48000
Pilot + front passenger	300	36	10800
Rear passengers	400	72	28800
Baggage	35	100	3500
Fuel: 30 gal ($\times$ 6 lb)	180	50	9000
Oil: 8 qt (2 gal $\times$ 7.5 lb)	15	-10	-150
Totals	2130	46.9	99950

STEP 2

STEP 1

STEP 2

STEP 3

STEP 3

- Computational Method
- Graph Method
- Table Method

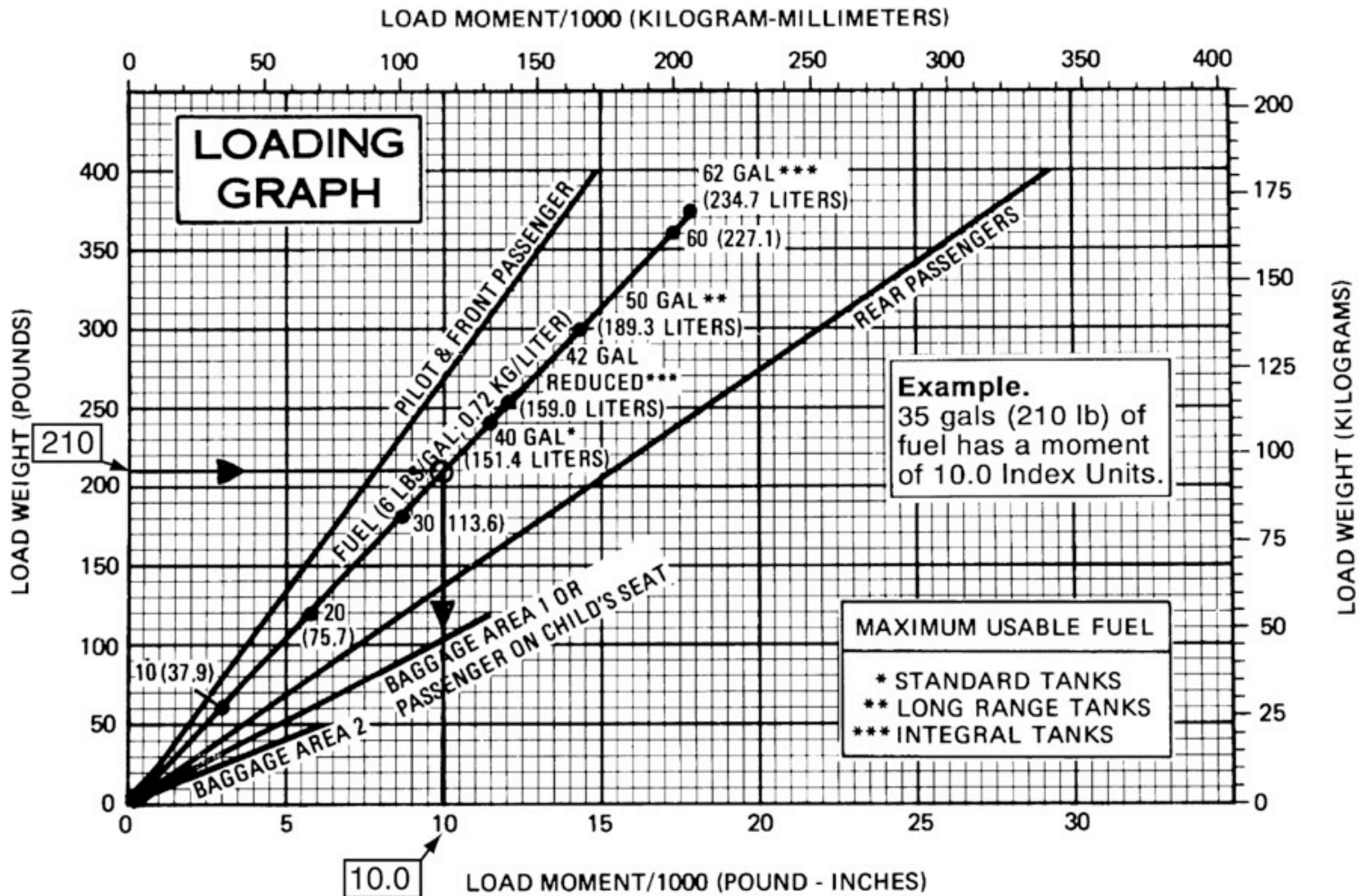
	Sample Loading Problem	Weight (lb)	Mom/1,000 (lb-in./1,000)
1	Basic empty weight (includes unusable fuel and full oil)	1463	56.9
2*	Usable fuel (35 gallons)	210	10
3	Pilot and front passenger	390	14.5
4	Rear passenger	260	19
5	Baggage area 1	54	5
6**	Baggage area 2	-	-
7	Ramp weight and moment	2377	105.4
8	Fuel allowance for start, taxi and runup	-7	-0.3
9***	Takeoff weight and moment	2370	105.1

Note that given figures are entered in white boxes. Calculated figures are in blue boxes.

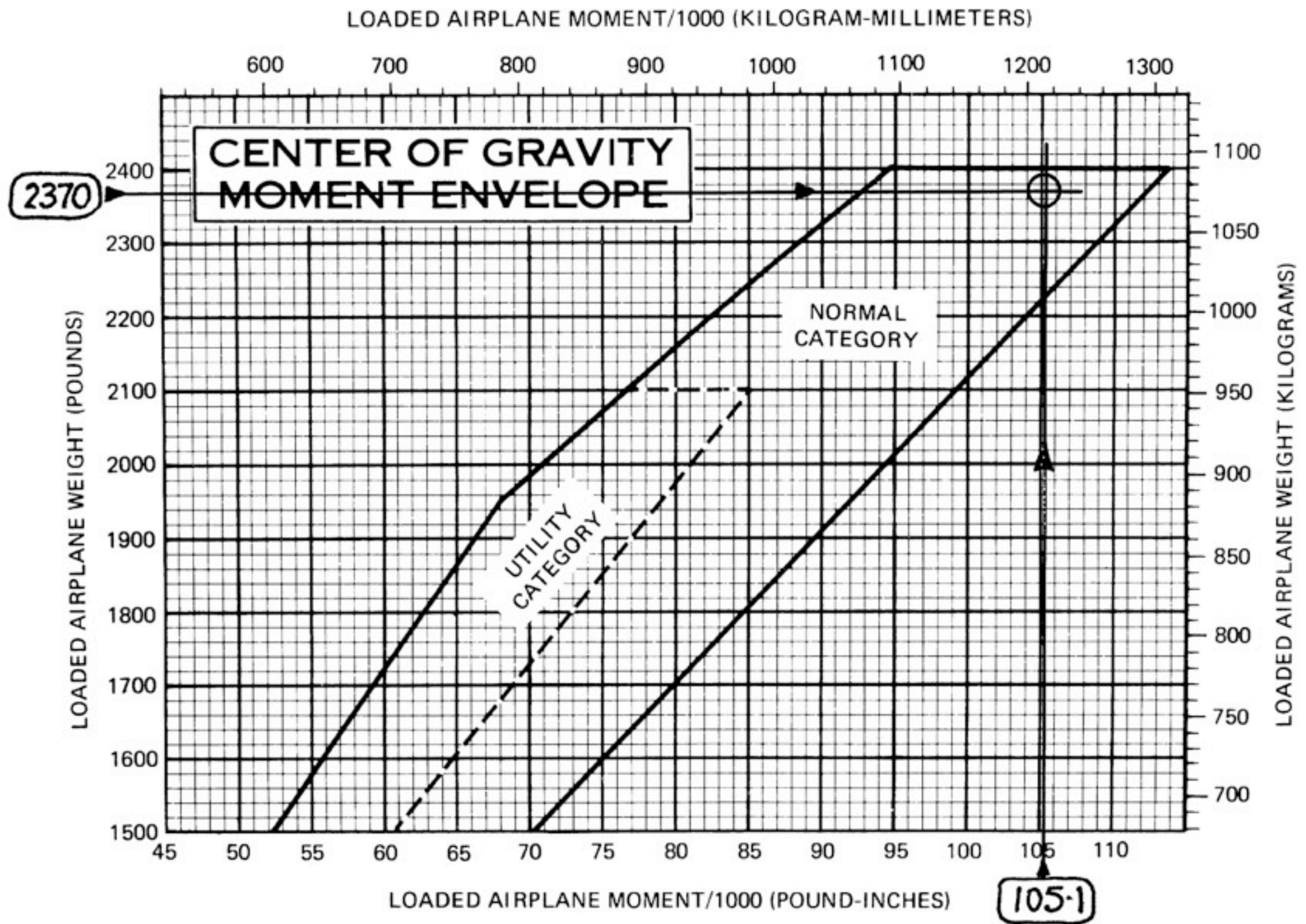
*35 gal @ 6 lb/gal = 210 lb. Enter loading graph with 210 lb, go across fuel line, and then read down to get 10.0 mom/1,000

**Add items 1 to 6

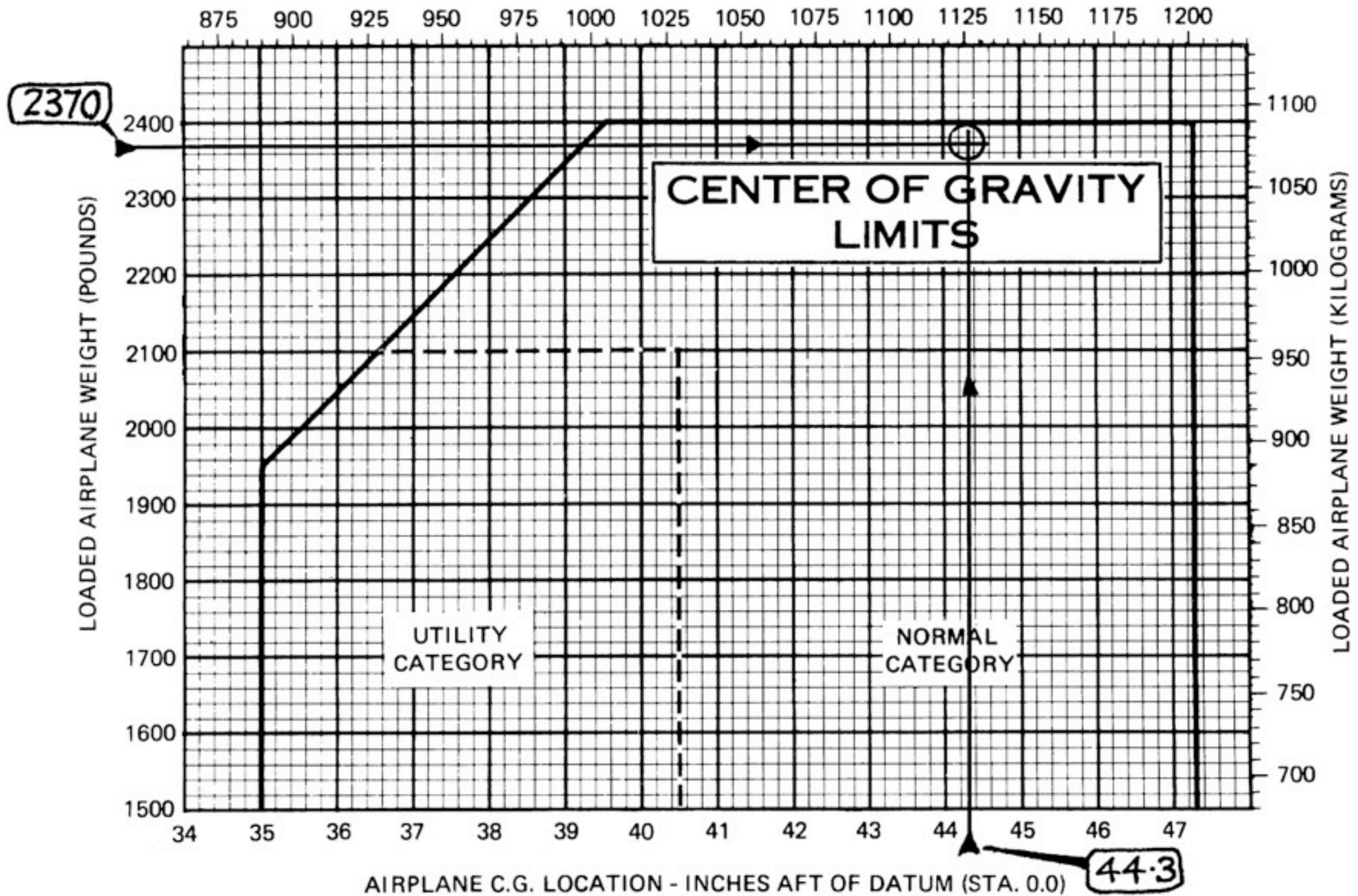
***Plot on CG Moment envelope Graph in figure 11-19 (page 299)



NOTE: Line representing adjustable seats shows the pilot or passenger center of gravity on adjustable seats positioned for an average occupant. Refer to the Loading Arrangements diagram for forward and aft limits of occupant C.G. range.



AIRPLANE C.G. LOCATION - MILLIMETERS AFT OF DATUM (STA. 0.0)



USEFUL LOAD WEIGHTS AND MOMENTS

OCCUPANTS

FRONT SEATS ARM 85		REAR SEATS ARM 121	
Weight	<u>Moment</u> 100	Weight	<u>Moment</u> 100
120	102	120	145
130	110	130	157
140	119	140	169
150	128	150	182
160	136	160	194
170	144	170	206
180	153	180	218
190	162	190	230
200	170	200	242

USABLE FUEL

MAIN WING TANKS ARM 75		
Gallons	Weight	<u>Moment</u> 100
5	30	22
10	60	45
15	90	68
20	120	90
25	150	112
30	180	135
35	210	158
40	240	180
44	264	198

*OIL

Quarts	Weight	<u>Moment</u> 100
10	19	5

*Included in basic Empty Weight

Empty Weight ~ 2015

MOM / 100 ~ 1554

MOMENT LIMITS vs WEIGHT

Moment limits are based on the following weight and center of gravity limit data (landing gear down).

WEIGHT CONDITION	FORWARD CG LIMIT	AFT CG LIMIT
2950 lb (takeoff or landing)	82.1	84.7
2525 lb	77.5	85.7
2475 lb or less	77.0	85.7

BAGGAGE OR 5TH SEAT OCCUPANT ARM 140

Weight	<u>Moment</u> 100	Weight	<u>Moment</u> 100
10	14	150	210
20	28	160	224
30	42	170	238
40	56	180	252
50	70	190	266
60	84	200	280
70	98	210	294
80	112	220	308
90	126	230	322
100	140	240	336
110	154	250	350
120	168	260	364
130	182	270	378
140	196		

AUXILIARY WING TANKS ARM 94

Gallons	Weight	<u>Moment</u> 100
5	30	28
10	60	56
15	90	85
19	114	107

MOMENT LIMITS vs WEIGHT

Weight	Minimum Moment 100	Maximum Moment 100	Weight	Minimum Moment 100	Maximum Moment 100	Weight	Minimum Moment 100	Maximum Moment 100
2100	1617	1800	2400	1848	2057	2700	2144	2303
2110	1625	1808	2410	1856	2065	2710	2155	2311
2120	1632	1817	2420	1863	2074	2720	2166	2319
2130	1640	1825	2430	1871	2083	2730	2177	2326
2140	1648	1834	2440	1879	2091	2740	2188	2334
2150	1656	1843	2450	1887	2100	2750	2199	2342
2160	1663	1851	2460	1894	2108	2760	2210	2350
2170	1671	1860	2470	1902	2117	2770	2221	2358
2180	1679	1868	2480	1911	2125	2780	2232	2366
2190	1686	1877	2490	1921	2134	2790	2243	2374
2200	1694	1885	2500	1932	2143	2800	2254	2381
2210	1702	1894	2510	1942	2151	2810	2265	2389
2220	1709	1903	2520	1953	2160	2820	2276	2397
2230	1717	1911	2530	1963	2168	2830	2287	2405
2240	1725	1920	2540	1974	2176	2840	2298	2413
2250	1733	1928	2550	1984	2184	2850	2309	2421
2260	1740	1937	2560	1995	2192	2860	2320	2428
2270	1748	1945	2570	2005	2200	2870	2332	2436
2280	1756	1954	2580	2016	2208	2880	2343	2444
2290	1763	1963	2590	2026	2216	2890	2354	2452
2300	1771	1971				2900	2365	2460
2310	1779	1980	2600	2037	2224	2910	2377	2468
2320	1786	1988	2610	2048	2232	2920	2388	2475
2330	1794	1997	2620	2058	2239	2930	2399	2483
2340	1802	2005	2630	2069	2247	2940	2411	2491
2350	1810	2014	2640	2080	2255	2950	2422	2499
2360	1817	2023	2650	2090	2263			
2370	1825	2031	2660	2101	2271			
2380	1833	2040	2670	2112	2279			
2390	1840	2048	2680	2123	2287			
			2690	2133	2295			