AIRCRAFT WEIGHT AND BALANCE

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CALCULATING WEIGHT AND BALANCE

There are two main ways to determine the loaded weight and balance for an aircraft.

Using this student activity, you will learn:

1. **COMPUTATIONAL METHOD**

   Use basic math to determine the total loaded weight of the aircraft and the CG. Apply these calculations against the aircraft's allowable maximum gross weight and CG range as specified in the *Pilot's Operating Handbook*.

2. **GRAPH METHOD**

   Use the graphs provided by the manufacturer in the *Pilot's Operating Handbook*. The graphs calculate the moments and allow you to determine if your aircraft is loaded within limits. You will find the graphs to complete this activity in **Aircraft Weight and Balance Student Notes 1**.

COMPUTATIONAL METHOD

You and a friend are planning to fly your Aeronca Champion (a two-person, high-wing, single-engine airplane) to a local airport for a hamburger. A Champion is a tandem airplane, meaning the seating is arranged so the two occupants are sitting directly ahead or behind one another. In the Champion, the pilot sits in the front seat. You weigh 170 pounds and your friend weighs 150 pounds. You have a 10 pound flight bag with you that will be stored in the baggage compartment. You are planning to fill the airplane up with fuel before you take off. Your tanks hold a total of 15 gallons of aviation gas.

The airplane's paperwork lists the basic empty weight as 782 pounds. The *Pilot's Operating Handbook* lists the following as weight and balance limitations:

CG Range	**10.9 - 21.5 inches**
Maximum Gross Weight	**1320 pounds**

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STEPS

Determine the weight and balance for this flight using the steps below.

1. List the weight of the aircraft, occupants, fuel, and baggage. Remember that aviation fuel weighs 6 pounds per gallon.
2. Enter the moment for each item listed. Remember: weight x arm = moment
3. Find the total weight and moment.
4. The CG is the total moment divided by the total weight.

ITEM	WEIGHT	ARM	MOMENT
Empty Weight	782	19.37	15147
Usable Fuel	90	-19	-1710
Pilot	170	12	2040
Passenger	150	46	6900
Baggage	10	68	680
TOTALS	**1202**		**23057**
CG = 19.1			

CG = Total Moment / Total Weight

CG = (23057 / 1202)

CG = 19.1 inches

QUESTIONS

1. Is the weight within limits? Is the CG within limits? Is the CG closer to the forward or rear limit?

The weight of 1202 pounds is under the maximum gross weight of 1320 pounds and the CG, at 19.1 inches, is within the limits of 10.9 to 21.5 inches. It's closer to the rear limit, which means the loading is slightly aft.

2. Why is the arm for fuel in the Aeronca Champ a negative number?

The arm for fuel is negative because the fuel tanks are located to the left (or forward) of the datum.

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GRAPH METHOD

You are piloting a Cessna 172S on an overnight trip. You plan to carry two friends. You weigh 155 pounds and your friends weigh 185 pounds and 160 pounds. You also want to carry about 50 pounds of camping equipment and 50 gallons of fuel. Will you be able to make this trip as planned? Use the graphs on the following pages to find the moments and ensure that the aircraft falls within weight and CG limits. (Hint: Put your lighter passenger in the back seat.)

The airplane's paperwork lists the basic empty weight as 1642 pounds with a moment of 62,600.

STEPS

Determine the weight and balance for this flight using the steps below. Refer to the graphs in **Aircraft Weight and Balance Student Notes 1** to determine the moments and whether or not your aircraft is within balance limits.

1. Fill in the table below with the weight for each item that is going into your airplane. Remember that fuel weighs 6 lbs/gallon.

2. Use the Loading Graph (FIGURE 1) to find the moment for the weights at each station.
    - For the 172S, the loading graph uses a "moment index" where the moment is divided by a constant. In this case, the constant is 1,000. The purpose of a moment index is to simplify weight and balance computations where heavy items and long arms result in large numbers.
        - In this scenario, the moment for the basic empty weight of your Cessna 172S is 62.6 (62,600 / 1000 = 62.6).
    - To determine the moment for the fuel, you must first convert 50 gallons to a weight. Aviation fuel weighs 6 lbs/gal.
    - To find the moment of the fuel, locate 300 on the left-hand vertical scale of the Loading Graph. Draw a line straight across to the angled line labeled "Fuel." Where the horizontal line intersects the angled fuel line, draw a line down to the horizontal scale to read approximately 14.5. That is the moment of the fuel.
    - Using the loading graph, fill in the moments for the pilot and front passenger, the rear passenger, and the baggage.

3. Add up the total weight and moment for your airplane loaded on the ramp.

4. Subtract the change in fuel and moment that will come from fuel you'll use before takeoff. Cessna uses a standard of 8 pounds (and .4 moment) as an allowance for start, taxi, and takeoff fuel. You now have the total takeoff weight and total takeoff moment for your loaded aircraft.

5. Use the Center of Gravity Moment Envelope (FIGURE 2) to determine if your aircraft's loading is within limits. Draw a line for both total weight and total moment on the CG envelope graph. If the lines intersect within the envelope, the aircraft is loaded within limits.

6. The Center of Gravity Moment Envelope graph is an alternate approach to determining if your aircraft is loaded within limits.
    - Determine the CG of your loaded aircraft by taking the total moment divided by the total weight. If you've been using a moment index, you must convert your moment back to the full number before running the calculation.
    - To determine if your aircraft's loading is within limits, draw a line for both total weight and CG. If the lines intersect within the envelope, the aircraft is loaded within limits.

ITEM	WEIGHT	MOMENT
Basic Empty Weight	1642	62.6
Usable Fuel	300	14.5
Pilot and Front Passenger	340	13
Rear Passengers	160	12
Baggage Area A	50	5
Baggage Area B	0	0
RAMP WEIGHT & MOMENTS (add columns)	**2492**	**107.1**

Fuel allowance for start, taxi, and runup	-8	-.4
TAKEOFF WEIGHT & MOMENT	**2484**	**106.7**
CG = 42.95 inches		

QUESTIONS

3. What is the aircraft's total weight, moment, and CG?

   2,484 pounds; 106,700 pound-inches; 42.95 inches

4. Is the aircraft within limits? Which category does it fall into?

   Yes - the aircraft is within both weight and CG limits. As loaded in this scenario, the 172S falls within the "Normal" category.

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