Center of Gravity Computation

Note applicable to Chapters 4 and 5: The ATP Single-engine exam (ATS) focuses on the Cessna 208 and the ATP Multi-engine exam (ATM) focuses on the Bombardier CRJ200 and 0400.

The start of the solution to any weight and balance problem is the calculation of the total weight of the aircraft (gross weight) and the total moment. All weight and balance problems on the ATP test use a moment index rather than the actual moment. The moment index is the actual moment divided by 1,000.

Basic Operating Weight (BOW) is defined as the empty weight of the aircraft plus the weight of the required crew, their baggage and other standard items such as meals and potable water. The BOW and the Basic Operating Index (Moment/1,000) are the same for all questions.

The Moment Index (MOM/1,000) is calculated by using the formula:

Weight x Arm/1,000 = MOM/1,000

The Center of Gravity (CG) in inches aft of the Datum line can be determined by using the formula:

CG = Total Moment / Total Weight

Since some FAA questions use a Moment Index instead of Moment, for these it is necessary to modify this formula by multiplying the (Total Moment/Total Weight) by the reduction factor (1,000). The formula then becomes:

CG = (Total Moment Index / Total Weight) x 1,000

Stabilizer Trim Setting

The correct horizontal stabilizer trim setting is very critical for proper takeoff performance of jet aircraft. The main determinants are the CG location and possibly the flap setting. Some aircraft, such as the DC-9, have their stabilizer trim indicators calibrated in percent of MAC, so it is necessary to calculate the CG to know the trim setting. Other aircraft (such as the B-737 and B-727) have their trim indicators marked off in units of nose up trim. In such cases it is necessary to refer to the trim table to determine the proper setting for a given CG. See FAA Figure 55.

The **Stab Trim Setting Table** at the bottom left side of FAA Figure 55 is used to determine the takeoff trim setting for a B-737. CG location in percent of MAC is used to determine the setting. For example, if the CG is at 8.0% of MAC, the stab trim setting is 7-3/4 units ANU (Airplane Nose Up).

The Stab Trim Setting Table at the left side of FAA Figure 83 is used to determine the takeoff trim setting for a B-727. Flap setting and CG location in percent of MAC are used to determine the setting. For example, if the CG is at 28% of MAC and the flaps are set at 15°, the stab trim setting is 4-1 /2 units ANU.

Changing Loading Conditions

Whenever weight is either added to or subtracted from a loaded airplane, both the gross weight and the center of gravity location will change. The solution to such a calculation is really a simplified loading problem. Instead of calculating a weight and moment for every section of the aircraft, it is only necessary to compute the original weight and moment—then, the *effect* of the change in weight. Often in these problems, the original CG is expressed in percent of MAC and it is necessary to convert this to an arm for the entire aircraft.

For example, if an aircraft's total weight was 8,600 pounds, and you shifted 100 pounds from station (or, arm) 100 to arm 150, a simple weight shift formula can be applied:

$$\frac{\text{Weight to be Shifted (100 pounds)}}{\text{Total Weight (8,600 pounds)}} = \frac{\text{Change in CG}}{\text{Distance CG Shifted (50 inches)}}$$

This is solved easily by cross-multiplying: 50 x 100 ÷ 8,600 = .06 inches. Therefore, the CG shifts .06 inches aft.

C208 Weight and Balance

Note: By definition, "basic empty weight" does not include crew weight, so you must include crew in the calculation. By definition, "basic operating weight" includes crew weight so you do not include crew in the calculation.

The other key to C208 weight and balance is to use the actual arms listed (FAA Figure 405) for each position. You can use the charts and pre-calculated moments as depicted in FAA Figure 412, but the actual calculation is more accurate and probably quicker. The only exception to this is fuel, as the arm changes based upon fuel weight, therefore the chart in FAA Figure 411 should be used.

Beech 1900 Weight and Balance

Note: By definition, "Basic Empty Weight" does not include crew weight, so you must include crew in the calculation. By definition, "Basic Operating Weight" includes crew weight so you do not include crew in the calculation.

Floor Loading Limits

In addition to ensuring that an aircraft is loaded within its weight and balance limits, it is important to make sure that the floor of a cargo compartment is not overloaded. The load limit of a floor is stated in pounds per square foot. The questions on the test require you to determine the maximum load that can be placed on a pallet of certain dimensions.

For example: what is the maximum weight that may be carried on a pallet which has the dimensions of 37 x 39 inches, when the floor load limit is 115 pounds per square foot, the pallet weight is 37 pounds, and the weight of the tiedown devices is 21 pounds?

The first step is to determine the area of the floor (in square feet) covered by the pallet. This is done by multiplying the given dimensions (which calculates the area in square inches) and dividing by 144 (which converts the area to square feet):

37 inches x 39 inches ÷ 144 square inches = 10.02 square feet.

The next step is to determine the total weight that the floor under the pallet can support, by multiplying the area times the floor load limit given in the question:

10.02 square feet x 115 pounds per square foot = 1, 152.39 pounds.

The final step is to determine the maximum weight which can be placed on the pallet by subtracting the weight of the pallet and the tiedown devices from the total load limit:

1,152.39 pounds - 58 pounds = 1,094.39 pounds.

The weight on the pallet must be equal to or less than this number (1,094.39, in this example). If it is more than this number, the combination of cargo, pallet, and tiedown weight would exceed the floor load limit. A review of the test questions reveals that the closest answer choice is always equal to or slightly less than the floor limit. All the calculations in this section were performed with a calculator carrying all digits to the right of the decimal point forward for the next step of the problem. The explanations show only two places to the right of the decimal.

A variation of the pallet loading problem is to determine the minimum floor load limit (in pounds per square foot) required to carry a particular loaded pallet. For example: what is the minimum floor load limit to carry a pallet of cargo with a pallet dimension of 78.9 inches x 98.7 inches, and a combination weight of pallet, cargo, and tiedown devices of 9,896.5 pounds?

The first step is to determine the floor area, multiplying the dimensions and dividing by 144 (78.9 x 98.7 ÷ 144 = 54.08 square feet). The second step is to determine the minimum required floor limit by dividing the total weight of the pallet, cargo, and tiedowns by the pallet area (9,896.5 ÷ 54.08 = 183.00 pounds). The correct answer must be at or above this weight (183.00 pounds, in this example).