Airline Pilot Training & Pilot Career Development

Airline Transport Professionals

For Written Prep Customers

Formulas to Understand For Your Computerized Exam

The Formulas included in the following pages are provided for your review and study. Once you understand the concept of these formulas, you should memorize the numbered steps used to calculate the answers. If you understand the formula concepts and know the steps to calculate the answers, you will be able to solve the problems in the exam with efficiency and accuracy.

TIME TO DUMP FORMULA:

Steps:

Know This

1) Calculate Fuel Burn to Touchdown using:

$$\text{Minutes to Touchdown} * \frac{\text{Number of Engines Operating} * \text{Fuel Burn Rate /Eng.}}{60 \text{ min}}$$

2) Calculate Fuel to be disposed of using:

Cruise Wt.
\- Landing Wt.

3) Calculate Fuel to dump using:

Fuel to be disposed
\- Fuel burn to Touchdown

4) Calculate Time to Dump using:

$$\frac{\text{Fuel to Dump}}{\text{Dump Rate}}$$

Sample Question:

How many minutes of dump time would be required to reach maximum landing weight at touchdown under the following conditions?

Number of engines 3
Cruise weight ..... 169,225 lb
Max. landing weight ..... 142,500 lb
Average fuel flow during dumping and descent to touchdown ..... 2,970 lb/hr/eng
Time from start dump to landing ..... 24 min
Fuel dump rate ..... 2,300 lb/min

Example:

Fuel burn = 2,970 lb./hr/eng

$$24 \times \frac{3 \times 2{,}970}{60 \text{ min}} = 3{,}564 \text{ lb.}$$

Cruise weight	169,225 lb.
Landing weight	- 142,500 lb.
Fuel to be disposed	26,725 lb.
Fuel burn	- 3,564 lb.
Fuel to dump	23,161 lb.

$$\text{Time to dump} = \frac{23{,}161 \text{ lb.}}{2{,}300 \text{ lb. / min}} = \mathbf{10.1 \text{ min.}}$$

NAUTICAL MILES PER 1000 lbs. FUEL:

Steps:

▶ Know This ◀

1) Calculate TAS using:

Speed of Sound * Cruise Mach

2) Calculate Distance using:

TAS * Hours Flown

3) Calculate NM/1000 lbs. of Fuel using:

$$\frac{\text{Distance}}{1000}$$

Sample Question:

An airplane has been cruising for 2 hours and 15 minutes at a speed of Mach .82. Total fuel consumed during this period has been 27,250 pounds. If Mach 1.0 is 595 knots, what has been the NM per 1,000 pounds of fuel?

Example:

TAS = 595 kts. x 0.82 = 488 kts.

Distance = 488 kts. x 2.25 hrs. = 1098 NAM

$$\frac{\text{NAM}}{1{,}000 \text{ lbs.}} = \frac{1{,}098}{27.250} = \mathbf{40.3}$$

CALCULATE CG:

Steps:

▶ Know This ▶

Calculate Total Weight using:

Wt(1) + Wt(2) + Wt(3)

Calculate Total Moment using:

Moment(1) + Moment(2) + Moment(3)

Calculate CG using:

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

Sample Question:

Based on this information, where would the
CG be located?
Weight No. 1 ..... 601 lb at 45 in. aft of datum
Weight No. 2 ..... 700 lb at 145 in. aft of datum
Weight No. 3 ..... 125 lb at 185 in. aft of datum

Example:

ITEM	WEIGHT	x	ARM	=	MOMENT
Wt. No. 1	601		45		27,045
Wt. No. 2	700		145		101,500
Wt. No. 3	125		185		23,125
TOTAL	1,426				151,670

$$\text{CG} = \frac{\text{TOTAL MOMENT}}{\text{TOTAL WEIGHT}} = \frac{151{,}670}{1{,}426} = \underline{106.36}$$

CALCULATE CG WHEN WT. ADDED:

Steps:

▶ Know This

1) Change Aircraft CG (% MAC) to CG index arm:

CG (% MAC) X MAC = CG (inches aft of LEMAC)

CG (inches aft of LEMAC) + LEMAC index arm = CG index arm

2) Calculate New Wt. using:

Total Wt. + Wt. Added

3) Calculate New Moment using:

Total Moment + Moment Added

3) Calculate New CG using:

New Moment

New Weight

Sample Question:

(Refer to appendix 3, figure 44.) Where is the new CG if the weight is added to the aft compartment under Loading Conditions WS-2?

LOADING CONDITIONS	WS-1	WS-2	WS-3	WS-4	WS-5
LOADED WEIGHT	90,000	85,000	84,500	81,700	88,300
LOADED CG (% MAC)	22.5%	28.4%	19.8%	30.3%	25.5%
WEIGHT CHANGE (POUNDS)	2,500	1,800	3,000	2,100	3,300

FWD COMPT CENTROID – STA 352.1 AND –227.9 INDEX ARM
AFT COMPT CENTROID – STA 724.9 AND +144.9 INDEX ARM
MAC – 141.5 INCHES, LEMAC – STA 549.13, AND –30.87 INDEX ARM

FIGURE 44.—DC-9 – Weight Shift.

Example:

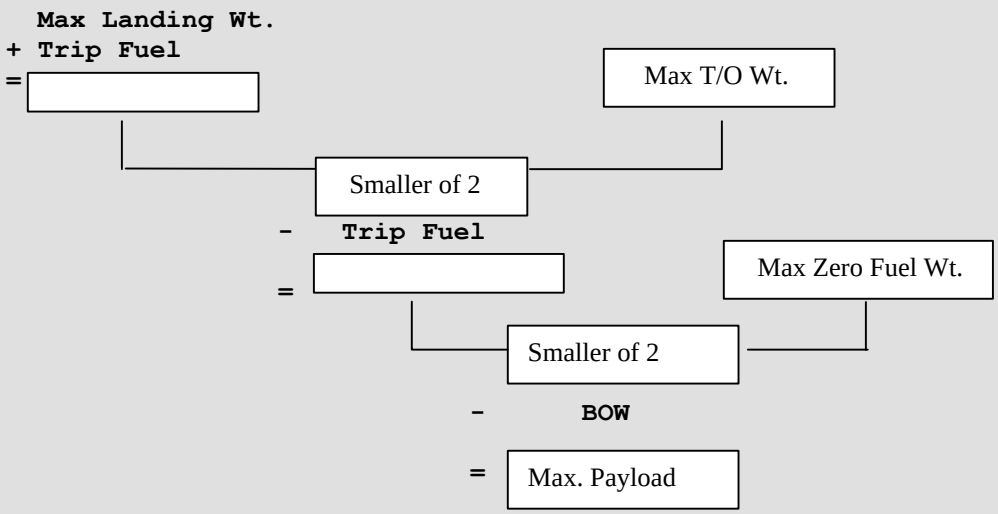
```
          CG % MAC        =          0.284
          MAC             =        X 141.5
                                   --------
          CG aft of LEMAC =          40.19
          LEMAC index arm =        - 30.87
          CG index arm    =        =  9.32
                                   --------

ITEM          WT/1,000  x  ARM    = MOM/1,000
Aircraft          85.0    9.32         792.2
Wt. Added       + 1.8   144.9        + 260.8
               --------              -----------
NEW               86.8                1053.0

          NEW MOMENT   1053.0
New CG = ----------- = ---------- = 12.13 inches
          NEW WEIGHT     86.8
```

MAX PAYLOAD:

Steps:

Know This

1) Calculate Max Payload using:



Sample Question:

What is the maximum payload under these conditions?
Basic operating weight ..... 100,500 lb
Max. zero fuel weight ..... 138,000 lb
Max. landing weight ..... 142,000 lb
Max. takeoff weight ..... 184,200 lb
Fuel tank load ..... 54,000 lb
Est. fuel burn en route ..... 40,000 lb

Example:

	MAX. LIMIT	TRIP LIMIT
Landing weight	142,000	142,000
+ Trip fuel		+ 40,000
Takeoff weight	184,200	182,000

Using the smaller of the two takeoff weights:

	MAX. LIMIT	TRIP LIMIT
Takeoff weight	182,000	182,000
- Fuel load		- 54,000
Zero fuel weight	138,000	128,000

Using the smaller of the two weights:

	TRIP LIMIT
Zero fuel weight	128,000
- BOW	- 100,500
Pay load	**27,500**

CALCULATE AMOUNT OF WEIGHT THAT MUST BE MOVED TO MOVE CG A GIVEN AMOUNT:

Steps:

▶ Know This ◀

1) Calculate Total Moment Shift using:

Total Weight * CG Shift

2) Calculate Change in Arm using:

Old Arm – New Arm

3) Calculate Amount of Weight to Move using:

$$\frac{\text{Total Moment Shift}}{\text{Change in Arm}}$$

Sample Question:

A cargo airplane loaded to a maximum takeoff gross weight of 165,000 pounds is tail heavy. How many 50 pound boxes must be moved from Station 1200.0 to Station 710.0 to move the CG forward 3.2 inches?

Example:

ITEM	WEIGHT	x ARM	= MOM/1,000
TOTAL	165,000	- 3.2	- 528

Change in arm = 1200.0 - 710.0 = 490.0 in.

$$\text{WEIGHT} = \frac{\text{MOMENT}}{\text{ARM}} = \frac{-528{,}000}{-490} = 1{,}078 \text{ lbs.}$$

(22 Boxes)

CALCULATE CG WHEN WT. SHIFTED:

Steps:

Know This

1) Calculate New Wt. Using:

Total Wt. – Wt. Removed + Wt. Added

2) Calculate New Moment using:

Total Moment - Moment Removed + Moment Added

3) Calculate New CG using:

$$\text{New CG} = \frac{\text{New Moment}}{\text{New Weight}}$$

Sample Question:

May 1,000 pounds of baggage be shifted
from Station 30.0 to Station 120.0 without
exceeding the aft CG limit?
Total weight ..... 147,500 lb
CG location ..... Station 115.8
Aft CG limit ..... Station 118.0

Example:

ITEM	WT/1,000	x ARM	= MOM/1,000
Aircraft	147.5	115.8	17,080.5
Wt. Removed	- 1.0	30.0	- 30.0
Wt. Added	+ 1.0	120.0	+ 120.0
NEW	147.5		17,170.5

$$\text{New CG} = \frac{\text{NEW MOMENT}}{\text{NEW WEIGHT}} = \frac{17{,}170.5}{147.5} = \mathbf{116.41\ inches}$$

This number could then be compared to the CG limits in a chart referenced in the question.

These last two formulas are relatively simple, and although the questions given here as examples do not reflect actual questions on the exam, you should understand these concepts. As an integral part of some exam questions, you could be required to convert CG numbers back and forth between “Inches Aft of Datum” (or “CG Index”), “% MAC” and “Inches Aft of LEMAC”

CALCULATE CG IN % MAC:

Steps:

▶ Know This ◀

1) Calculate CG Aft of LEMAC using:

```
   CG Aft of Datum
-  LEMAC
   ---------------
```

2) Calculate Length of MAC using:

```
    TEMAC
-   LEMAC
    ------
```

3) Calculate New CG as a percent of MAC using:

$$\frac{\text{CG aft of LEMAC}}{\text{MAC}}$$

Sample Question:

If your CG Index is at 903.7 inches, your leading edge MAC is 860.2 inches, and your trailing edge MAC is at 1040.9, calculate your CG as a percent of MAC.

Example:

New CG aft of LEMAC:

```
CG aft of datum       =     903.7 in.
LEMAC                 =   - 860.2 in.
                          ------------
CG aft of LEMAC       =      43.5 in.
```

Length of MAC:

```
TEMAC          =   1040.9
LEMAC          =  - 860.2
                  --------
MAC            =    180.7
```

New CG as a percent of MAC:

$$\frac{\text{CG aft of LEMAC}}{\text{MAC}} = \frac{43.5}{180.7} = .2407 = 24.07\%\ \text{MAC}$$

CALCULATE CG IN INCHES AFT OF LEMAC:

Steps:

▶ Know This ◀

1) Calculate Length of MAC using:

```
   TEMAC
 - LEMAC
 ------
```

2) Calculate CG in % Inches Aft of LEMAC using:

%MAC * MAC

Sample Question:

Your LEMAC is 860.2 and your TEMAC is 1040.9, calculate your CG aft of LEMAC if your CG is at 20.7% of MAC.

Example:

Length of MAC:

TEMAC	=	1040.9
LEMAC	=	- 860.2
MAC	=	180.7

CG aft of LEMAC:

20.7% MAC = 0.207 x 180.7 = 37.4 in.

END