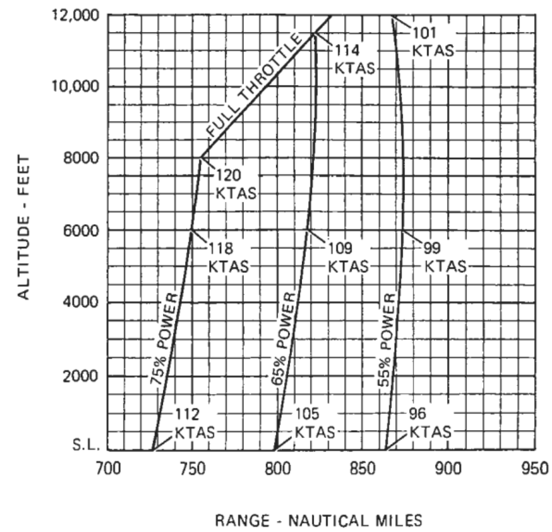
# Performance and Limitations

## Objective

To ensure the applicant learns the impact of weight and balance and environmental factors on aircraft performance, the importance of memorizing important aircraft limitations and how to calculate weight and balance and performance data.

## Purpose

Airplanes are designed to be as safe as possible and perform well under a variety of circumstances, but this safety and performance is based on pilots remaining within the published limitations and performance envelopes. This lesson introduces pilots to the procedures for calculating the various factors which affect airplane performance, as well as how to consider airplane performance and limitations during flight planning.




## Schedule

- **Ground Lesson**: 45 minutes
- **Student Q&A**: 15 minutes

## Equipment

- Airplane Checklist
- Airplane POH
- Calculator
- Whiteboard / Markers (optional)

## Student Actions

- Ask any questions, receive study material for the next lesson.
- Watch linked video.
- Review listed references.

## Instructor Actions

- Deliver the ground lesson (below).
- Answer student questions.

## Completion Standards

- Student can explain the following concepts:
  - How to compute Weight and Balance, the dangers of being out of the envelope, weight effects on performance
    - Datum, weight, gross weight, arm, moment
    - Strategies for dealing with an airplane out of the allowable weight and balance envelope
  - How to compute takeoff, landing, and cruise performance
  - List airplane V speeds and what they represent
  - Effects of density altitude, wind, runway surfaces, etc.
  - Importance of calculating required performance, differences from actual performance, safety margin

## References

- Cyndy Hollman - “Takeoff Performance (Private Pilot Lesson 7c)”
    - YouTube - https://www.youtube.com/watch?v=3OKXUI5le30
- Airplane POH - Section 2 [Limitations], Section 5 [Performance], Section 6 [Weight & Balance]
- FAA-H-8083-25C (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 4, Page 4-4 [Density Altitude], Chapter 5, Page 14-15 [Static and Dynamic Stability], Chapter 5, Page 15-17 [Longitudinal Stability], Chapter 5, Page 19-20 [Directional Stability], Chapter 5, Page 25-26 [Stalls], Chapter 5, Page 34-35 [Load Factors and Stalling Speeds], Chapter 5, Page 37-38 [Vg Diagram], Chapter 10, Page 2 [Effects of Weight], Chapter 10, Page 2-4 [Balance, Stability, Center of Gravity], Chapter 10, Page 4-5 [Terms and Definitions], Chapter 10, Page 5-11 [Computing W&B], Chapter 11, Page 16-18 [Landing Performance], Chapter 11, Page 19-28 [Performance Charts]
- FAA-S-ACS-6C (Private Pilot ACS) - Area I Task F
- FAA-S-ACS-7B (Commercial Pilot ACS) - Area I Task F
- FAA-S-ACS-25 (CFI ACS) - Area II Task F

## Ground Lesson Outline

- Importance of Weight and Balance - Dangers of Imbalance
- Weight and Balance Terms - Weight, Gross Weight, Basic Empty Weight, Arm, Station, Moment, Datum, CG
- Effect of Weight and Balance on Performance
    - Weight raises AoA for level flight, Affects stall speed, takeoff and landing distance, maneuvering speed
    - CG - Affects stall speed, stability
- Methods of Weight and Balance Control
    - Moving or reducing passengers or cargo, Adjusting fuel load, Ballast
- Computing Weight and Balance - Airplane POH Section 6 [Weight & Balance]
    - How To Compute - Total Moment, Check Flight Envelope - Normal Category/Utility Category
    - Adding, Removing, and Shifting Loads
- POH Performance Charts - Airplane POH Section 5 [Performance]
    - Takeoff Performance, Climb Performance, Cruise Performance, Landing Performance
    - Fuel Burn, TAS, Endurance
- Airplane Limitations - Airplane POH Section 2 [Limitations]
    - V Speeds - Airplane, Flaps Extended, Gear Extended Max Speeds
    - Max Demonstrated Crosswind - Not a true limitation
    - Vg Diagram, Load Factor, Dangers of Exceeding Limitations
- Effects of Atmospheric Conditions on Performance
    - Wind, Temperature, Pressure
    - True Altitude, Pressure Altitude, Density Altitude
    - Effect on Takeoff and Landing Speeds
- Required Performance
    - Determining sufficient airplane performance for planned flight
        - Also consider: Hard/Soft Surface, Airport Environment (Runway Slope)
    - Effects of Configuration
    - Calculated Performance vs. Actual Performance
        - Pilot Skill, Aircraft Condition, Improper Leaning
        - Safety Margin

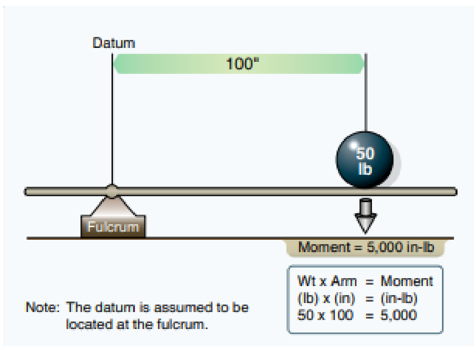
## Common Errors

- **Failing to consider changes in passenger, cargo, or fuel load on weight and CG calculations.**
- Miscalculating the CG when loading changes.

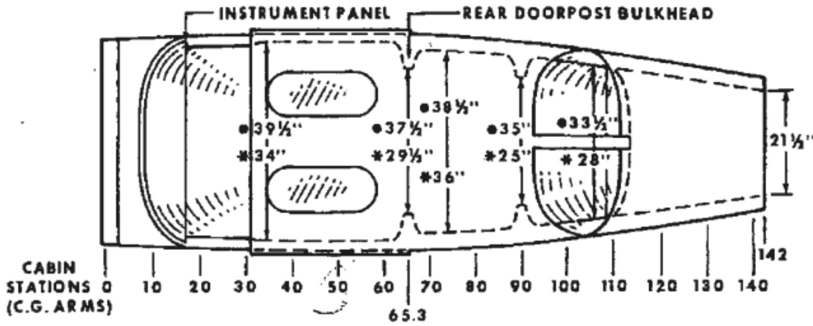
# Ground Lesson Content

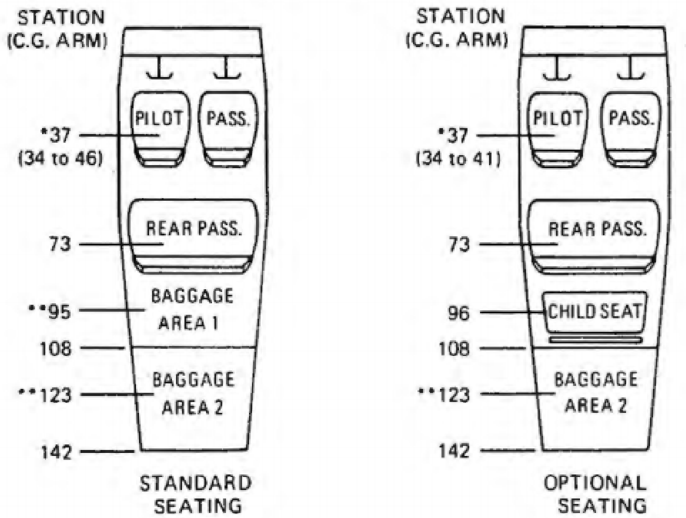
- **Importance of Weight and Balance -** It is quite intuitive that the heavier an airplane is, the more force is required to make it fly, or to maneuver it. Airplanes are extremely sensitive to weight, and are designed to operate only in specific ranges of minimum and maximum weights. Additionally, airplanes are quite sensitive to *balance*, which refers to the location of the Center of Gravity.
    - **Dangers of Imbalance -** Airplanes in flight rely on their flight control surfaces to produce sufficient forces to maneuver and control the airplane. Large imbalances in weight distribution can lead to situations where the airplane is excessively nose heavy, or tail heavy, or wants to roll one direction or another.

- **Weight and Balance Terms**
    - **Weight -** Simply, how heavy is the airplane overall (*gross weight*), or how heavy the individual object is, whether than be passengers, cargo, or even fuel or airplane parts.
        - **Maximum Gross Weight -** Maximum weight allowable for the airplane.
        - **Basic Empty Weight -** Weight of the airplane with all standard and optional equipment, plus any unusable fuel. Does *not* include weight of usable fuel, passengers, or cargo.
        - **Useful Load -** Difference between Maximum Gross Weight and Basic Empty Weight. Load usable for fuel, passengers, and cargo.
        - **Payload -** Load available after fuel is loaded.
    - **Datum -** A given point on the airplane from which all relative distances are measured. For instance, the position of all objects in the plane can be specified in the number of inches from the tip of the propeller spinner, or any other location. The datum can be imagined as the fulcrum in a balance or scale.

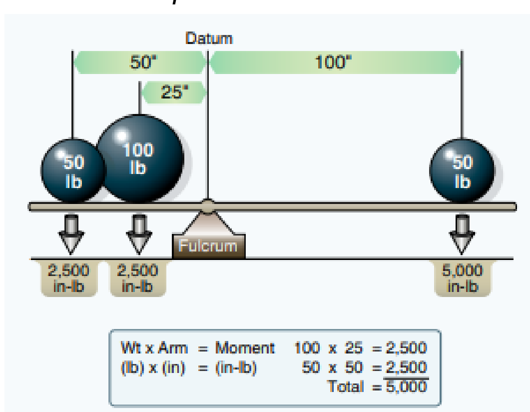



    - **Arm -** The *distance* from the datum. The further that an object is from the datum, the longer the arm. Arm is usually expressed as *inches aft of datum* (positive arm numbers) or *inches forward of datum* (negative arm numbers). **This is also sometimes called a *station* in some POHs.**

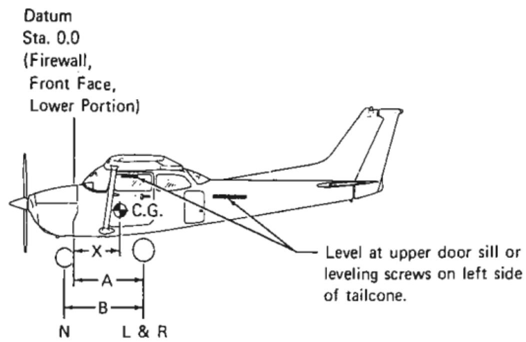


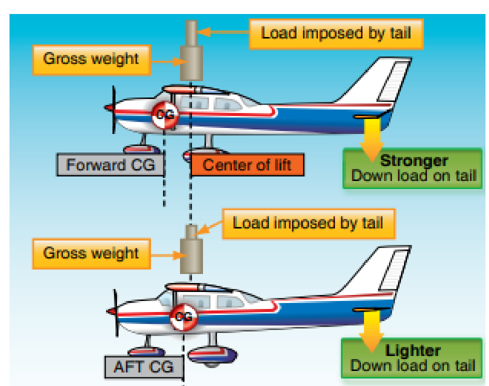

- **Moment -** In the 'balance scale' concept, moment simply describes the tendency of an object to rotate around the datum. A 50lb object 100 inches from the datum wants to rotate more than a 50lb object 50 inches from the datum. **This is intuitively experienced with levers: the longer the lever, the less force must be applied to achieve the same result.** When using a scale, a heavier object on one side can be balanced by lighter objects on the other, if those lighter objects are further away from the fulcrum. Moment is calculated by multiplying **`Weight x Arm`**, and is usually expressed in '*inch pounds*'.




- **CG -** Once all individual weights in an aircraft are considered, the *Center of Gravity* (CG) represents a sort of 'average position' of the weights. **When balancing an object by a fingertip, objects balance on their center of gravity.** When computing weight and balance for airplanes, the position of the CG is assumed to be some distance from the datum, represented as an *arm*, or *inches aft of datum*.

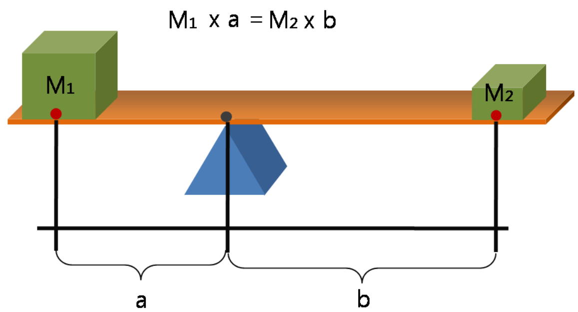



- **Effect of Weight and Balance on Performance**
  - **Weight**
    - **Takeoff and Landing Performance** - Heavier airplanes require **more runway to take off, and require more runway to land**.
    - **Stall Speed** - When flying at higher weights, the total load on the wing is higher, and the airplane must produce more lift to maintain straight and level flight. This requires a higher angle of attack for the same airspeed. Because airplanes always stall at the same angle of attack, and heavier weights increase angle of attack, it can be concluded that **heavier aircraft stall at a higher airspeed.**
    - **Load Factor** - Airplane load factors (maximum and minimum structural loads) are computed only for allowable ranges of airplane weights. **Exceeding these weights may cause structural failure in flight!** This is especially true when encountering turbulence, etc.
    - **Maneuvering Speed** - Likewise, flying at very light weights also affects performance, because it will require less flight control movement to produce the same forces. Recall that the wing will be flying at a lower angle of attack when the weight is lower, which means that the wing can produce more total lift before it stalls. **This can result in the airplane exceeding the limit load factor at lower airspeeds!**
  - **CG** - The position of the Center of Gravity affects many aspects of airplane performance and stability:
    - **Longitudinal Stability and Stall Recovery** - *Longitudinal stability* refers to an airplane's **stability in pitch**. Most airplanes are stable in pitch, and have a gentle up-down pitch oscillation over time. The most important factor in longitudinal stability is the location of the center of gravity relative to the center of lift.
      - **Center of Gravity and Center of Lift** - When conventionally designed airplanes fly, the center of gravity is always *in front of* the center of lift. You can think of the center of lift as a sort of pivot point in a seesaw. Because the horizontal stabilizer is far behind the center of lift, it produces *downward* force (essentially lift, but downward) to keep the nose of the airplane level. This downward force opposes the upward force of the main

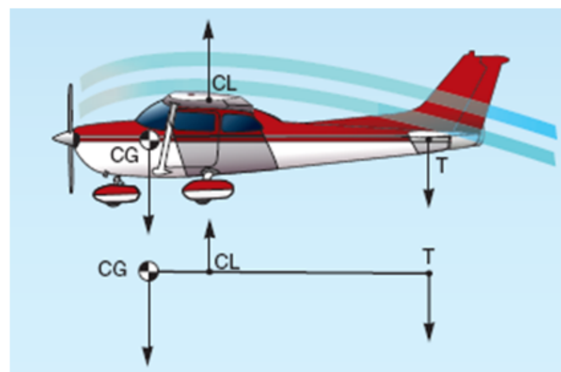


wing, requiring it to produce slightly more lift to compensate. Also, because any airfoil that produces lift also produces drag, the amount of drag caused by the horizontal stabilizer depends on the force it must produce.

- When the center of gravity is further forward, the horizontal stabilizer must produce more downward force to raise the nose, which adds to the loads placed on the Center of Lift pivot point (the main wing).



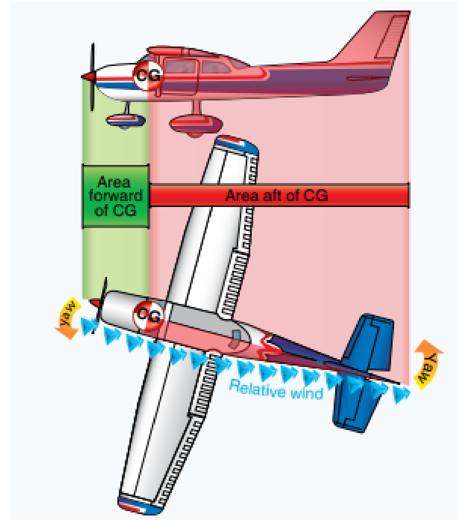

- Airplanes are designed so that they have a natural tendency to recover from a stall. **A well-designed airplane's Center of Gravity is always forward of the Center of Lift.**




- This design causes a natural tendency for the airplane to nose down, reducing the angle of attack. To counteract this, the horizontal stabilizer and elevator surfaces of an airplane are designed to produce a *downward* force, which 'holds up' the heavier nose area by pivoting the airplane around the Center of Lift. **When an airplane stalls, if the elevator pressure is relaxed, the Center of Gravity will fall naturally.**
- As the Center of Gravity moves closer to the Center of Lift, the natural nose-down stall-recovery tendency is weakened, and it requires less downward force by the tail to move the nose up or down. **In this configuration, relatively small movements of the elevator can cause large, rapid changes in pitch.** When an airplane Center of Gravity is too close to the Center of Lift, or even behind it, a very dangerous situation exists where there is no natural tendency to recover from a stall. **In fact, if the Center of Gravity is too far rearward (aft), the airplane may be uncontrollable in pitch and a stall may be unrecoverable!** This situation is called *longitudinal instability*.

- **Stall Speed** - Similar to the natural tendency for a forward CG to cause the airplane to recover from a stall, a forward CG requires the rear horizontal stabilizer to produce more downward force to keep the nose raised for level flight. This in turn adds more weight for the main wing to support, increasing its angle of attack, and therefore increasing stall speed.

- **Directional Stability** - *Directional stability* is stability in yaw. Airplane yaw is largely controlled by the vertical tail surface, and to a lesser extent, the fuselage itself. Due to the large distance from the center of gravity, the tail surface is very effective at maintaining directional stability. **When the CG moves rearwards, towards the tail, the tail surface is less effective and directional stability is reduced.**

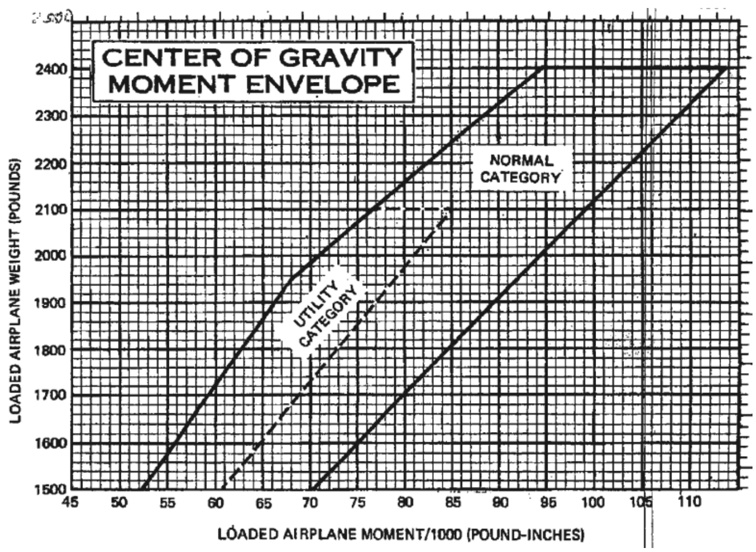



- **Methods of Weight and Balance Control** - Pilots have a few ways to manage the weight and balance of an airplane.
  - **Moving or reducing passengers or cargo** - If the weight is too much, the amount of passengers or cargo can be reduced. Similarly, if the issue is merely that of balance, it is possible that simply *moving* the passengers or cargo to another location can alleviate the problem.
  - **Adjusting fuel load** - Airplanes often carry significant amounts of fuel, which can be reduced to give a higher *payload* (weight carrying capability for passengers and cargo).
  - **Ballast** - If the issue is solely one of CG, it is often possible to add relatively small weights to baggage compartments to generate large changes in the CG, since baggage compartments are often far from the datum.

- **Computing Weight and Balance** - In order to determine the total weight and find the Center of Gravity for an airplane, the *Gross Weight* and *CG location* must be computed.
  - **How To Compute** - Computing weight and balance is fairly simple:
    - **Step 1**: Start with the *Airplane's Empty Weight and CG*. This can be found in the POH, and **represents the Gross Weight and CG location with no (usable) fuel, passengers, or cargo.** *See your Airplane POH Section 6 [Weight & Balance]*
    - **Step 2**: Add the weight of fuel, passengers, and cargo to the Airplane Empty Weight. This is the *gross weight*.
    - **Step 3**: Multiply the weight of each item (fuel, each passenger and item of cargo) by the *arm* for their location. This provides the *moment* for each item. Compute the moment of the empty airplane by multiplying the Airplane Empty Weight by the empty CG. (Some W&B sheets already provide this) This is the *empty moment*.
    - **Step 4**: Add each calculated moment to the empty moment to determine the *total moment*.
    - **Step 5**: Divide the *total moment* by the *gross weight*. **This provides the CG location, in terms of distance from the datum.**

| Item | Weight | Arm | Moment |
|---|---|---|---|
| Aircraft Empty Weight | 2,100 | 78.3 | 164,430 |
| Front Seat Occupants | 340 | 85.0 | 28,900 |
| Rear Seat Occupants | 350 | 121.0 | 42,350 |
| Fuel | 450 | 75.0 | 33,750 |
| Baggage Area 1 | 80 | 150.0 | 12,000 |
| | | | |
| Total | 3,320 | | 281,430 |
| | | | 281,430 ÷ 3,320 = 84.8 |

- **Check Flight Envelope -** Use the POH to find where the computed gross weight and CG lie within the envelope. Depending on the POH, you may need to use *total moment* or *CG (inches)*. **If the intersection between the weight and CG does not lie within the envelope, the airplane is not within the allowable CG range and weight must be added, removed, or moved to alter the CG!**
    - **Normal vs Utility Category -** Note that many airplanes may be operated in the *Utility Category* at certain ranges of weight and CG. If the maneuvers being planned require the airplane to be operated in this category, be sure to ensure the weight and CG are within limits for that area of the flight envelope.




- **Adding, Removing, and Shifting Loads -** It is also easy to compute what will happen to the weight or CG. The further from the datum (further towards the rear of the airplane) an object is placed, the more it will move the resulting CG rearwards.
    - For example, to simulate the adding of 10 lbs of ballast to the rear baggage area, simply multiply the weight of the ballast times the arm location of the baggage area, and add to the existing total moment, to see if the CG moves within limits. **Likewise, to simulate the removal of an item, compute a *negative* weight in the given location (giving a *negative* moment), and add it to the total moment.**

- **POH Performance Charts** - See your Airplane POH Section 5 [Performance]
  - **Takeoff Performance** - Use tables for calculations, take note of conditions and configuration!
    - **Important Note:** Table below is an *Example Only*. Use data from *your* airplane POH.

## TAKEOFF DISTANCE
### MAXIMUM WEIGHT 2400 LBS

**SHORT FIELD**

CONDITIONS:
Flaps 10°
Full Throttle Prior to Brake Release
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.

| WEIGHT LBS | TAKEOFF SPEED KIAS | | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LIFT OFF | AT 50 FT | | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS |
| 2400 | 51 | 56 | S.L. | 795 | 1460 | 860 | 1570 | 925 | 1685 | 995 | 1810 | 1065 | 1945 |
| | | | 1000 | 875 | 1605 | 940 | 1725 | 1015 | 1860 | 1090 | 2000 | 1170 | 2155 |
| | | | 2000 | 960 | 1770 | 1035 | 1910 | 1115 | 2060 | 1200 | 2220 | 1290 | 2395 |
| | | | 3000 | 1055 | 1960 | 1140 | 2120 | 1230 | 2295 | 1325 | 2480 | 1425 | 2685 |
| | | | 4000 | 1165 | 2185 | 1260 | 2365 | 1355 | 2570 | 1465 | 2790 | 1575 | 3030 |
| | | | 5000 | 1285 | 2445 | 1390 | 2660 | 1500 | 2895 | 1620 | 3160 | 1745 | 3455 |
| | | | 6000 | 1425 | 2755 | 1540 | 3015 | 1665 | 3300 | 1800 | 3620 | 1940 | 3990 |
| | | | 7000 | 1580 | 3140 | 1710 | 3450 | 1850 | 3805 | 2000 | 4220 | - - - | - - - |
| | | | 8000 | 1755 | 3615 | 1905 | 4015 | 2060 | 4480 | - - - | - - - | - - - | - - - |

  - **Climb Performance** - Use tables for calculations, take note of conditions and configuration!
    - **Important Note:** Table below is an *Example Only*. Use data from *your* airplane POH.

## MAXIMUM RATE OF CLIMB

CONDITIONS:
Flaps Up
Full Throttle

NOTE:
Mixture leaned above 3000 feet for maximum RPM.

| WEIGHT LBS | PRESS ALT FT | CLIMB SPEED KIAS | RATE OF CLIMB - FPM | | | |
|---|---|---|---|---|---|---|
| | | | -20°C | 0°C | 20°C | 40°C |
| 2400 | S.L. | 76 | 805 | 745 | 685 | 625 |
| | 2000 | 75 | 695 | 640 | 580 | 525 |
| | 4000 | 74 | 590 | 535 | 480 | 420 |
| | 6000 | 73 | 485 | 430 | 375 | 320 |
| | 8000 | 72 | 380 | 330 | 275 | 220 |
| | 10,000 | 71 | 275 | 225 | 175 | - - - |
| | 12,000 | 70 | 175 | 125 | - - - | - - - |

## TIME, FUEL, AND DISTANCE TO CLIMB

**MAXIMUM RATE OF CLIMB**

CONDITIONS:
Flaps Up
Full Throttle
Standard Temperature

NOTES:
1. Add 1.1 gallons of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10°C above standard temperature.
4. Distances shown are based on zero wind.

| WEIGHT LBS | PRESSURE ALTITUDE FT | TEMP °C | CLIMB SPEED KIAS | RATE OF CLIMB FPM | FROM SEA LEVEL | | |
|---|---|---|---|---|---|---|---|
| | | | | | TIME MIN | FUEL USED GALLONS | DISTANCE NM |
| 2400 | S.L. | 15 | 76 | 700 | 0 | 0.0 | 0 |
| | 1000 | 13 | 76 | 655 | 1 | 0.3 | 2 |
| | 2000 | 11 | 75 | 610 | 3 | 0.6 | 4 |
| | 3000 | 9 | 75 | 560 | 5 | 1.0 | 6 |
| | 4000 | 7 | 74 | 515 | 7 | 1.4 | 9 |

- **Landing Performance** - Use tables for calculations, take note of conditions and configuration!
  - **Important Note:** Table below is an *Example Only*. Use data from *your* airplane POH.

## LANDING DISTANCE

**SHORT FIELD**

CONDITIONS:
Flaps 30°
Power Off
Maximum Braking
Paved, Level, Dry Runway
Zero Wind

NOTES:
1. Short field technique as specified in Section 4.
2. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
3. For operation on a dry, grass runway, increase distances by 45% of the "ground roll" figure.
4. If a landing with flaps up is necessary, increase the approach speed by 7 KIAS and allow for 35% longer distances.

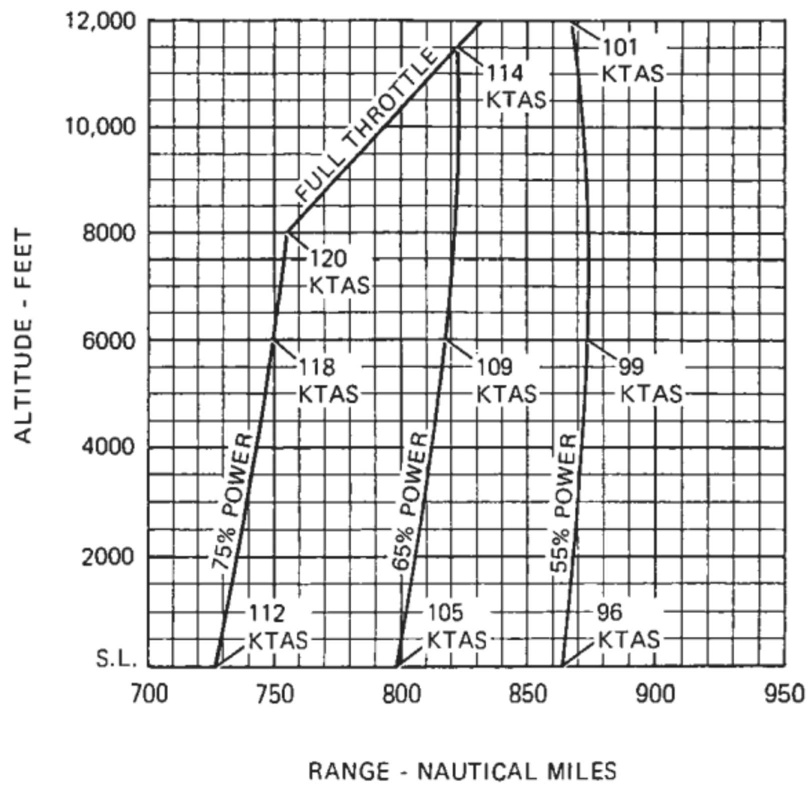
| WEIGHT LBS | SPEED AT 50 FT KIAS | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS | GRND ROLL FT | TOTAL FT TO CLEAR 50 FT OBS |
| 2400 | 61 | S.L. | 510 | 1235 | 530 | 1265 | 550 | 1295 | 570 | 1325 | 585 | 1350 |
| | | 1000 | 530 | 1265 | 550 | 1295 | 570 | 1325 | 590 | 1360 | 610 | 1390 |
| | | 2000 | 550 | 1295 | 570 | 1330 | 590 | 1360 | 610 | 1390 | 630 | 1425 |
| | | 3000 | 570 | 1330 | 590 | 1360 | 615 | 1395 | 635 | 1430 | 655 | 1460 |
| | | 4000 | 595 | 1365 | 615 | 1400 | 635 | 1430 | 660 | 1470 | 680 | 1500 |
| | | 5000 | 615 | 1400 | 640 | 1435 | 660 | 1470 | 685 | 1510 | 705 | 1540 |
| | | 6000 | 640 | 1435 | 660 | 1470 | 685 | 1510 | 710 | 1550 | 730 | 1580 |
| | | 7000 | 665 | 1475 | 690 | 1515 | 710 | 1550 | 735 | 1590 | 760 | 1630 |
| | | 8000 | 690 | 1515 | 715 | 1555 | 740 | 1595 | 765 | 1635 | 790 | 1675 |

- **Cruise Performance, Fuel Burn, TAS, Endurance** - Use tables for calculations, take note of conditions and configuration!

# CRUISE PERFORMANCE

CONDITIONS:
2400 Pounds
Recommended Lean Mixture (See Section 4, Cruise)

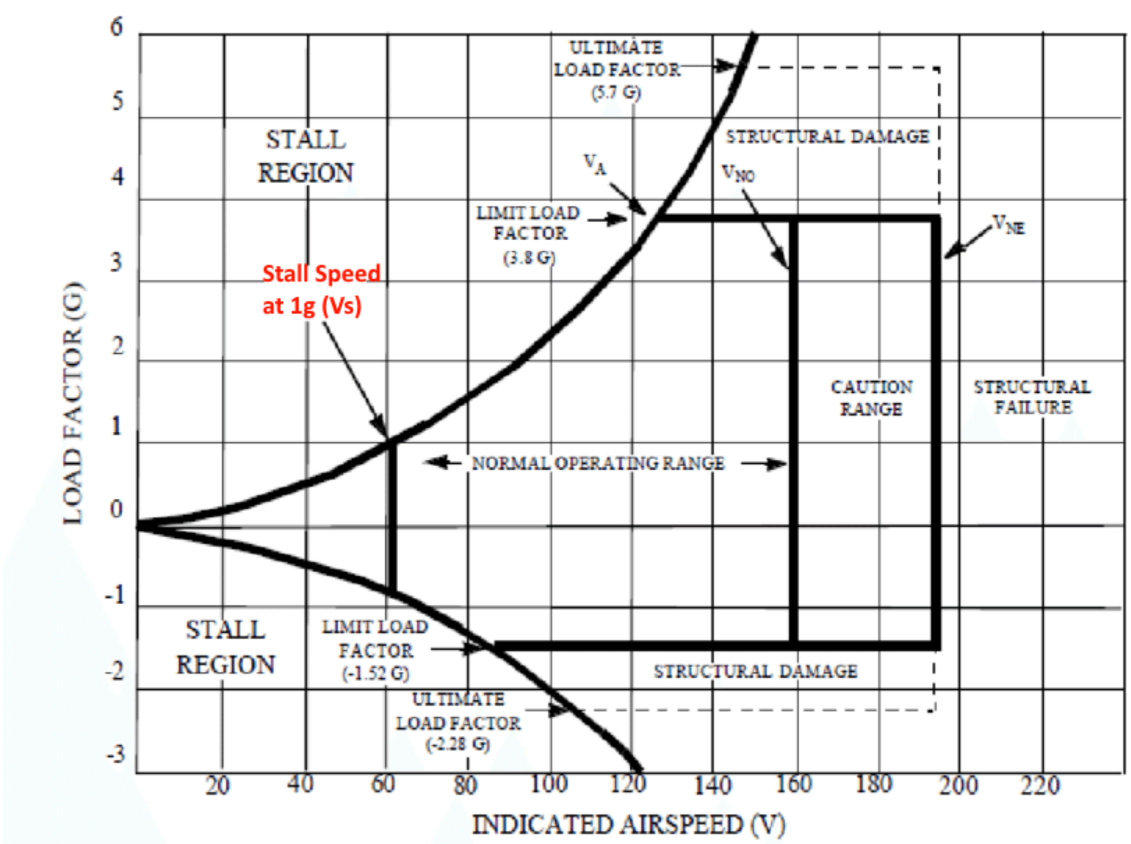
| PRESSURE ALTITUDE FT | RPM | 20°C BELOW STANDARD TEMP | | | STANDARD TEMPERATURE | | | 20°C ABOVE STANDARD TEMP | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | % BHP | KTAS | GPH | % BHP | KTAS | GPH | % BHP | KTAS | GPH |
| 2000 | 2500 | - - - | - - - | - - - | 76 | 114 | 8.5 | 72 | 114 | 8.1 |
| | 2400 | 72 | 110 | 8.1 | 69 | 109 | 7.7 | 65 | 108 | 7.3 |
| | 2300 | 65 | 104 | 7.3 | 62 | 103 | 6.9 | 59 | 102 | 6.6 |
| | 2200 | 58 | 99 | 6.6 | 55 | 97 | 6.3 | 53 | 96 | 6.1 |
| | 2100 | 52 | 92 | 6.0 | 50 | 91 | 5.8 | 48 | 89 | 5.7 |
| 4000 | 2550 | - - - | - - - | - - - | 76 | 117 | 8.5 | 72 | 116 | 8.1 |
| | 2500 | 77 | 115 | 8.6 | 73 | 114 | 8.1 | 69 | 113 | 7.7 |
| | 2400 | 69 | 109 | 7.8 | 65 | 108 | 7.3 | 62 | 107 | 7.0 |
| | 2300 | 62 | 104 | 7.0 | 59 | 102 | 6.6 | 57 | 101 | 6.4 |
| | 2200 | 56 | 98 | 6.3 | 54 | 96 | 6.1 | 51 | 94 | 5.9 |
| | 2100 | 51 | 91 | 5.8 | 48 | 89 | 5.7 | 47 | 88 | 5.5 |




- **Airplane Limitations** - See your Airplane POH Section 2 [Limitations]
  - **V Speeds** - It is crucial for pilots to ***memorize*** and stay within the V speeds of their airplane. Some important V-Speeds that pilots should know:
    - **Vs** - Stall speed (generally in clean configuration)
    - **$Vs_0$** - Stall Speed in landing configuration
    - **Vx** - Best Angle of Climb
    - **Vy** - Best Rate of Climb

- **Vg** - Best Glide
- **Vfe** - Max Flaps Extended
- **Vle** - Max Gear Extended Speed / Vlo - Max Gear Operating Speed
- **Va** - Maneuvering Speed
- **Vno** - Max Normal Operating Speed (Top of Green Arc)
- **Vne** - Never Exceed Speed
- **Max Demonstrated Crosswind** - Max Demonstrated Crosswind is not a true limitation, it is simply the maximum value that was demonstrated during certification. **However, pilots should consider their own proficiency with crosswind techniques when deciding how much crosswind is allowable.** There is an aerodynamic limit (unpublished) to how much crosswind is possible in an airplane.

- **Vg Diagram** - The Vg Diagram visually illustrates the various airplane speed limitations and how *Load Factor* affects stall speed, etc.




- **Dangers of Exceeding Limitations** - Exceeding published airplane limitations is extremely dangerous and can lead to in-flight structural failure!

- **Effects of Atmospheric Conditions on Performance**
  - **Wind, Temperature, Pressure** - POH Performance Charts generally account for these variables, as they can increase, or decrease performance.
  - **Measures of Altitude**
    - **True Altitude** - Actual altitude above Mean Sea Level (MSL) in absolute terms.
    - **Pressure Altitude** - Altitude above MSL corrected for non-standard pressure. (Std Pressure = 29.92”) Each 0.01” of deviation accounts for **10 feet** of correction. **When the atmospheric pressure is higher than standard, the pressure altitude is lower than the true altitude.**
    - **Density Altitude** - Altitude above MSL corrected for non-standard pressure *and* temperature. **This altitude is used primarily in performance calculations** since it

represents the "equivalent altitude" in the standard atmosphere (29.92" and 15° Celcius) where the same performance would be achieved.
- This is computed because both airplane aerodynamic performance *and* engine performance are affected by reduced density of the atmosphere.

- **Effect on Takeoff and Landing Speeds -** When Density Altitude is high, takeoff and landing *true airspeed* will be higher, although the airspeed indicator will display the same indicated airspeeds. **This equates to longer takeoff and landing distances!**

- **Required Performance**
  - It is crucial that pilots determine *before every flight* that the airplane has sufficient performance for the planned flight. Other factors to consider:
    - **Soft Runway Surfaces** increase takeoff rolls, and decrease landing rolls
    - **Airport Environment** - Upward sloping runways increase takeoff rolls, and decrease landing rolls. Obstacles in the approach or departure path may require a longer takeoff or landing roll.
  - **Effects of Configuration** - POH performance values are valid only for the specified configurations. If the POH specifies to use Flaps, Flaps must be used to meet the stated performance!
  - **Calculated Performance vs. Actual Performance** - The POH performance numbers should be treated as *best case* values. It is generally best to add some 'safety margin' to the computed numbers to account for things like:
    - **Pilot Skill -** Meeting calculated landing or takeoff distances requires good pilot technique. Any mistakes can increase these values.
    - **Aircraft Condition -** Airplanes which are older frequently fail to exactly match 'book values'.
    - **Improper Leaning** - It is very easy to perform the mixture leaning procedure improperly, which can make a large difference in actual fuel burn.
  - **Safety Margin** - Add 10-20% to takeoff or landing distances. Add 10-20% to fuel burn figures. Do not plan to conduct flights that require maximum performance, such as in extreme crosswinds, etc.