

# Performance and Limitations

# Objective

Gain an intuitive understanding of how atmospheric conditions affect aircraft performance, and how to use our airplane's performance charts to compute specific performance numbers.

# Motivation

Altitude, temperature, and pressure affect all aspects of our airplane's performance. All pilots need to understand how these factors affect the airplane, and what limitations are present in its design.

Instruction: Known to unknown, building on aerodynamics



# Overview

- Air and density
  - Density altitude
  - International Standard Atmosphere
  - Types of altitude
  - Types of airspeed
  - How density affects performance
- Airplane performance charts
  - Performance scenario using Cessna charts
  - Other chart styles
- Additional aircraft limitations

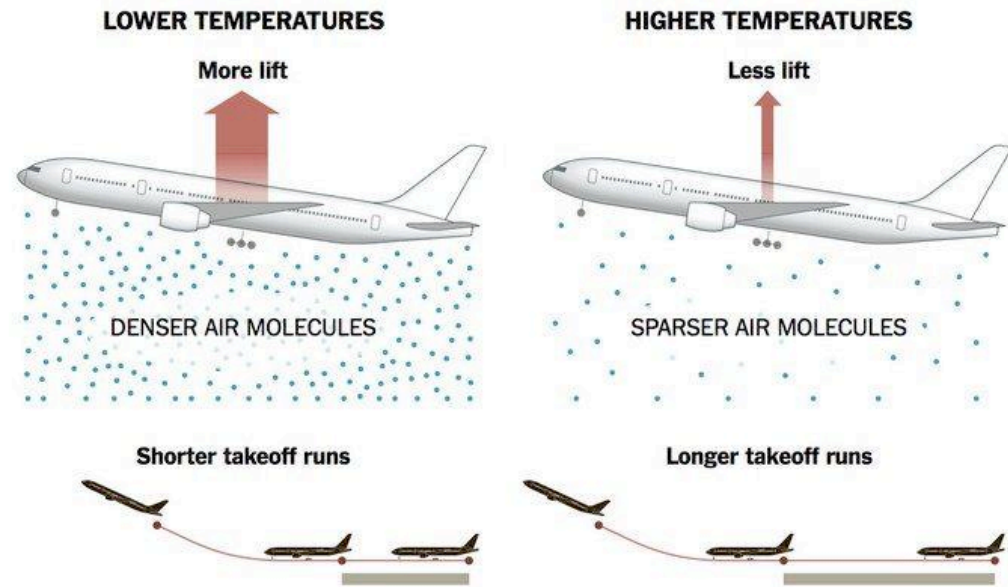
# Performance Concepts

# Air and Density

- Our airplane swims through the air, air molecules bounce off the airplane
  - As these air molecules are deflected downward, our airplane is forced upward
  - Our propeller pushes air backwards which pushes us forwards
  - Our engine "breaths" air from outside, burns that air with fuel to produce power

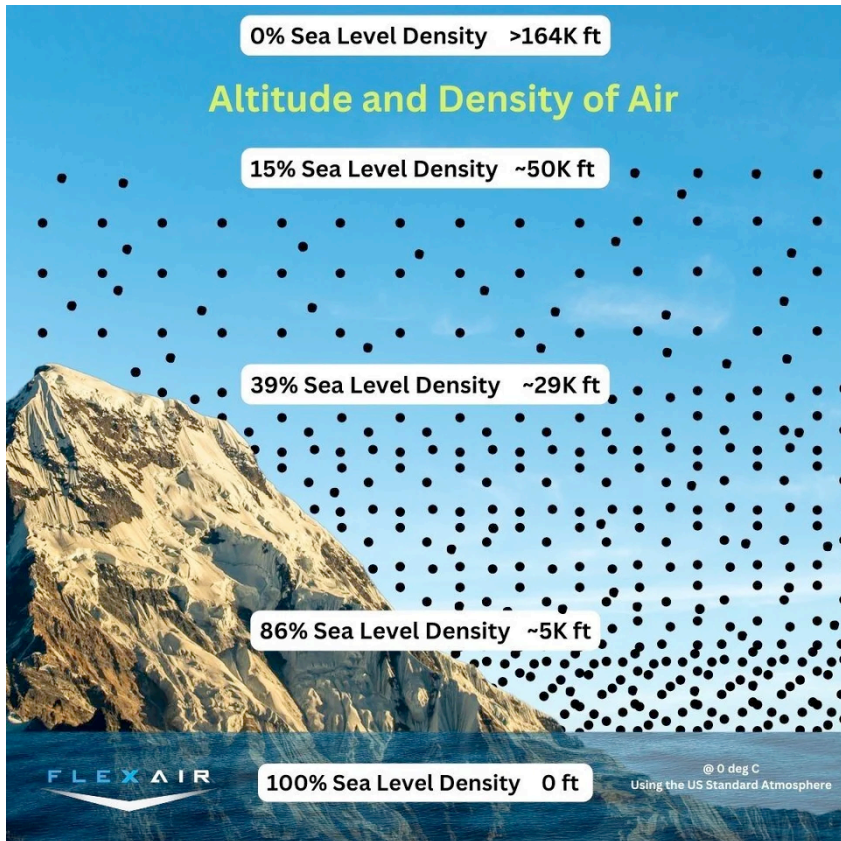
# High and Low Air Density

- All of this depends on how close the air molecules are together
- Tightly spaced = more air to grab on to
  - Wings can produce more lift
  - Propeller can produce more thrust
  - Engines can produce more power
- Density constantly changes with
  - i. Pressure
  - ii. Temperature
  - iii. Humidity



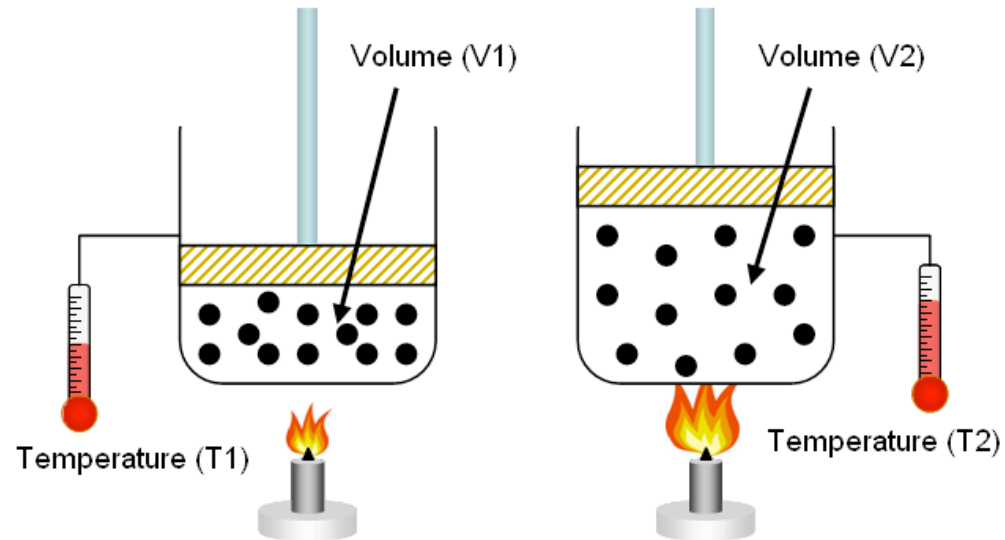
Source: National Oceanic and Atmospheric Administration | By The New York Times

# Thing That Affect Density: Ambient Pressure (Variable #1)



- As we climb
  - Ambient pressure decreases
  - Air density decreases
  - Pressure decreases on average 1" Hg per 1000' (*pressure lapse rate*)
- The pressure outside varies from day to day
  - On high pressure days, air is more dense
  - On low pressure days, air is less dense

## Things That Affect Density: Temperature (Variable #2)



- Hot air molecules bounce off each other more energetically
- This causes the molecules to spread out and become less dense
- Likewise, cold air molecules are less excited become more dense

## Humidity: Temperature (Variable #3)



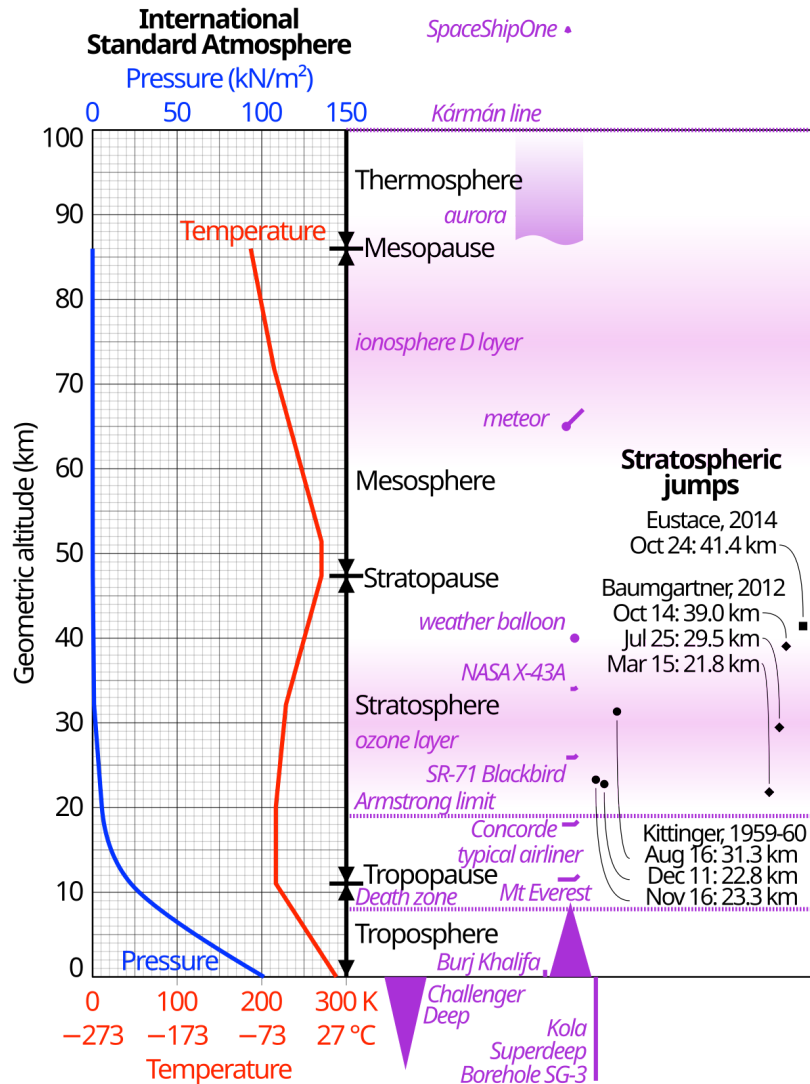
- Water vapor in the air also takes up space
- The higher the humidity, the lower the air density
- Effect of density is small relative to pressure and temperature
  - Usually omitted from performance charts and calculations

## Rolling it All Up

- That's a lot of variables to consider
- What if there was one number that would combine the effects of:
  - Altitude
  - Ambient pressure
  - Temperature



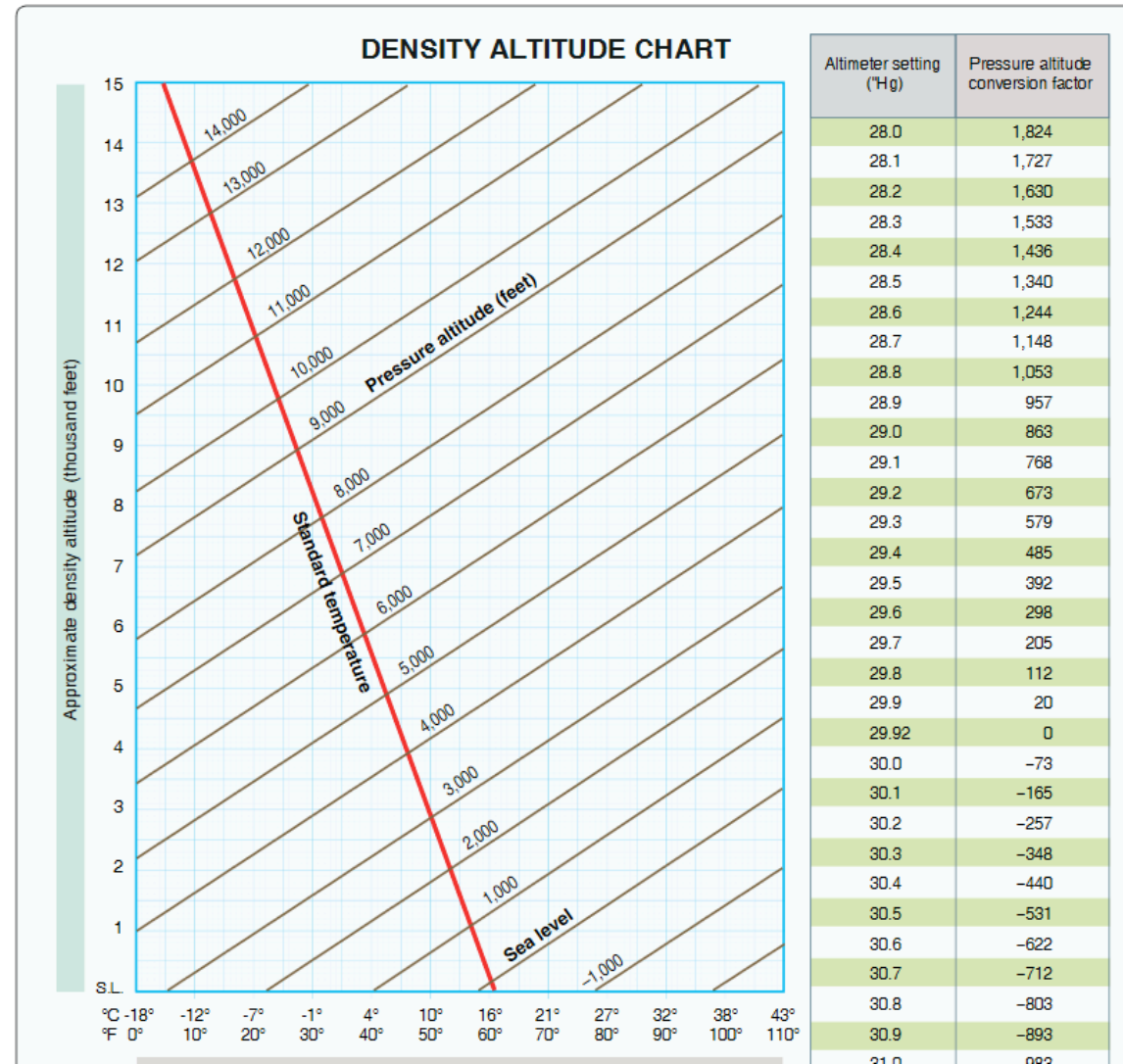
# International Standard Atmosphere (ISA)



- What if we made a fake atmosphere with known conditions?
  - Density can be defined as an altitude in this atmosphere
- The higher the altitude, the lower our airplane's performance
- ISA Definitions
  - At sea level, the pressure is 29.92" Hg
  - Pressure lapses (reduces) at 1" Hg per 1000'
  - Temperature: 15° C at S.L.
  - Temperature lapse rate: 2°C per 1000' (to

# Computing Density Altitude

Appendix 2



4000 ft. / 84° F, 29° C / 29.80" Hg

1. Start with field elevation: **4000 ft.**
2. Correct for Variable Ambient Pressure
  - $4000 + 112' = \mathbf{4112}$
  - *Pressure altitude*
3. Correct for Variable Temperature:
  - 4000' line & **29° F**
  - *~6700' density altitude*

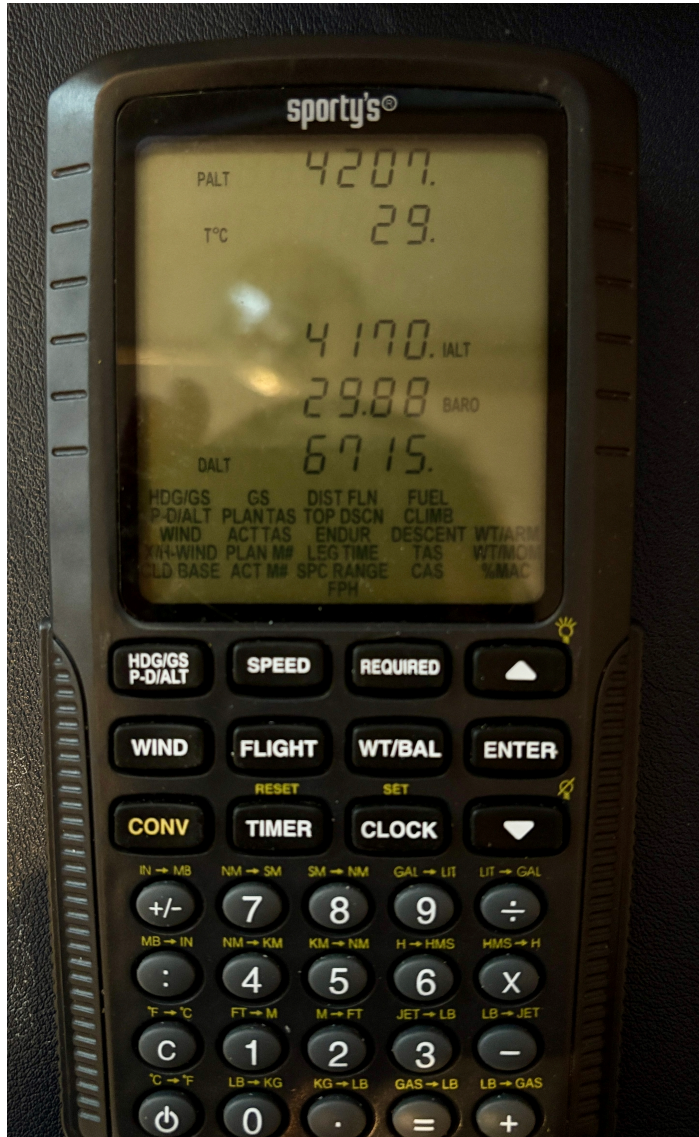
Notice higher temperature = Higher density altitude

## Pressure altitude another way: Have the altimeter do the math



- As you rotate the Kollsman window the altimeter moves up and down at that same rate 1" per 1000'
- If we set our altimeter to 29.92" (the pressure of S.L. in the standard atmosphere), it will give us pressure altitude

# Density Altitude with an Electronic 56-B



- P-D/ALT mode
- Set Indicated altitude - IALT
- Altimeter setting - BARO
- Outside temperature - T°C
- Gives
  - Pressure altitude PALT
  - Density altitude DALT

# Review of Altitude Types

- Ambient pressure/Altimeter setting: Set in the Kollsman window
- **Indicated** altitude: Read directly off the altimeter
- **Pressure** altitude: Height in the ISA where current pressure is found
- **Density** altitude: Height in the ISA where the current pressure is found, plus any correction for temperature

**Airspeed**



# Pitot Tube As A Molecule Counter



- More forward movement: More molecules we hit
- More air density: Molecules tightly spaced so more to hit
- Less air density: Molecules less tightly spaced, less to hit
- Tells us how many air molecules is moving over the wings

# Types of Airspeed: Calibrated Airspeed



- The pitot tube is attached at a certain angle
- This might not be directly into the relative wind
- With a high angle of attack, the relative wind will be at a steeper angle
- To account for this, we compute **calibrated airspeed**
  - This is usually given in a table in the POH



# Types of Airspeed: True Airspeed



- Adjusts the "molecule count" based on the air density
  - Uses the same 3 variables: Altitude, pressure, temperature
- True airspeed is the speed you're moving through the *air mass*

# True Airspeed with an Electronic E6B



ACT TAS Mode

Pressure altitude (PALT): 4210'

Outside air temperature (OAT): 29°C

Calibrated airspeed (CAS): 118 knots

Result TAS is **130.1 knots**

- This means we're flying *faster* through the air mass than the airspeed indicator would have us believe.
- With no wind, we'd be moving 130 knots over the ground

# Types Of Airspeeds



- **Indicated** airspeed (IAS): Read from altimeter
- **Calibrated** airspeed (CAS): Calibrated for position/instrument errors
  - At slow airspeeds this may be several knots off
- **True** airspeed (TAS): CAS corrected for altitude and nonstandard temperature
- **Ground** speed (GS): Actual speed over the ground
  - TAS adjusted for wind

# Knowledge Check

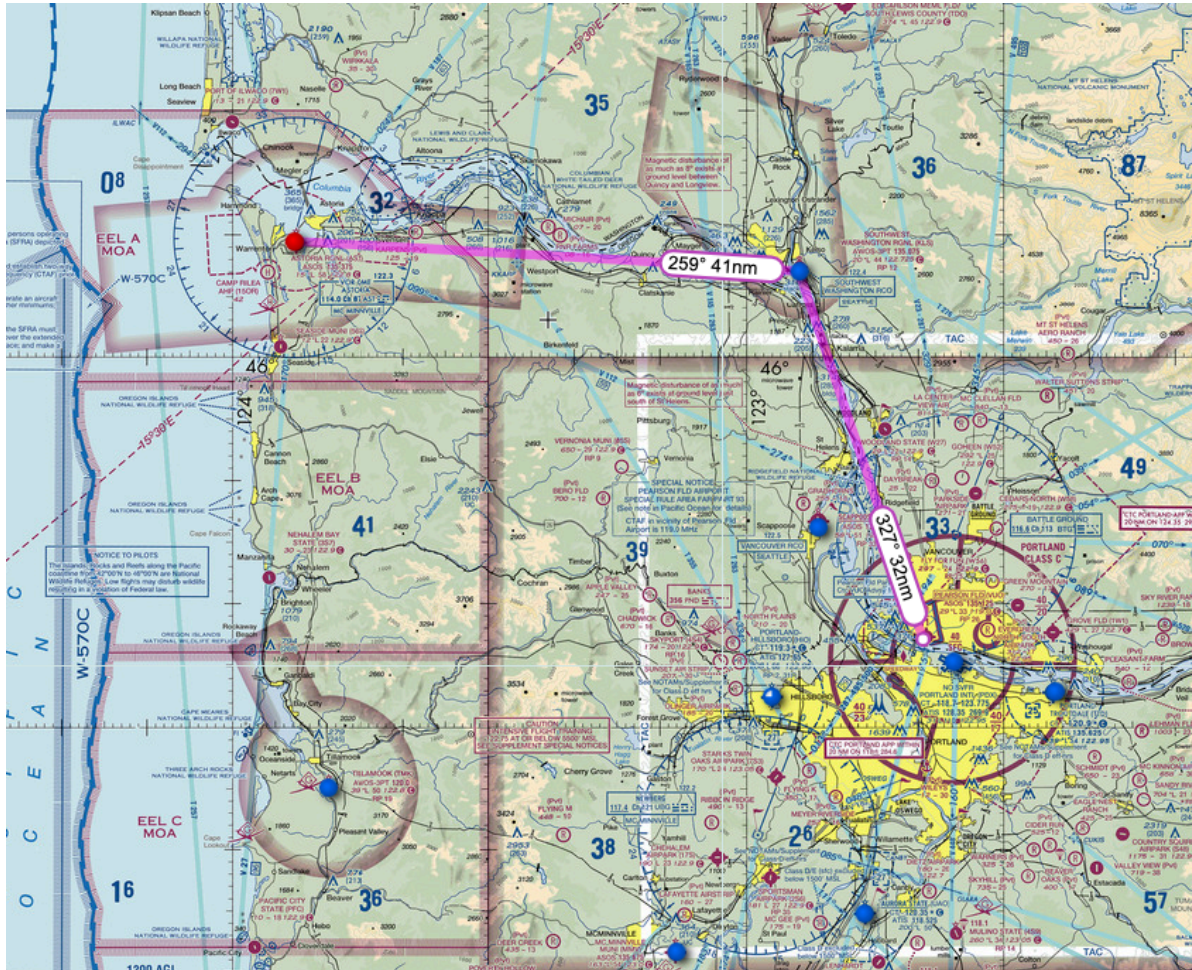
Assuming all other variables are the same:

- Where will an airplane have a longer takeoff roll, in Denver or in Orlando?
- Where will an airplane have a longer landing roll, when the temperature is 2° C or 30° C?
- Which aircraft will have a higher ground speed on takeoff, when the pressure is 20.79" or 30.44" Hg?
- When will our (normally-aspirated) airplane produce the most power, on the ground or at 8000 feet?

# Performance Planning



# Performance



On a real flight we want to know:

- How much runway distance we will use for takeoff
- How long the flight will take
- How much fuel we will burn
- How much landing distance we will use

# CRUISE PERFORMANCE

PRESSURE ALTITUDE 2000 FEET

## CONDITIONS:

3100 Pounds  
Recommended Lean Mixture  
Cowl Flaps Closed

## NOTE

For best fuel economy, operate at the leanest mixture that results in smooth engine operation or at peak EGT.

|      |    | 20°C BELOW<br>STANDARD TEMP<br>-9°C |      |      | STANDARD<br>TEMPERATURE<br>11°C |      |      | 20°C ABOVE<br>STANDARD TEMP<br>31°C |      |      |
|------|----|-------------------------------------|------|------|---------------------------------|------|------|-------------------------------------|------|------|
| RPM  | MP | %<br>BHP                            | KTAS | GPH  | %<br>BHP                        | KTAS | GPH  | %<br>BHP                            | KTAS | GPH  |
| 2400 | 25 | ---                                 | ---  | ---  | 78                              | 137  | 14.8 | 74                                  | 137  | 14.0 |
|      | 23 | 74                                  | 131  | 14.0 | 70                              | 131  | 13.3 | 66                                  | 130  | 12.6 |
|      | 21 | 65                                  | 125  | 12.4 | 62                              | 124  | 11.8 | 59                                  | 123  | 11.3 |
|      | 19 | 57                                  | 117  | 10.9 | 54                              | 116  | 10.5 | 51                                  | 115  | 10.0 |
| 2300 | 25 | 78                                  | 135  | 14.9 | 74                              | 135  | 14.1 | 71                                  | 134  | 13.4 |
|      | 23 | 70                                  | 129  | 13.3 | 67                              | 128  | 12.7 | 63                                  | 128  | 12.1 |
|      | 21 | 62                                  | 122  | 11.8 | 59                              | 121  | 11.3 | 56                                  | 120  | 10.8 |
|      | 19 | 54                                  | 114  | 10.4 | 51                              | 113  | 10.0 | 49                                  | 112  | 9.6  |
| 2200 | 25 | 75                                  | 132  | 14.2 | 71                              | 132  | 13.5 | 67                                  | 131  | 12.8 |
|      | 23 | 67                                  | 126  | 12.7 | 64                              | 126  | 12.1 | 60                                  | 125  | 11.5 |
|      | 21 | 59                                  | 119  | 11.3 | 56                              | 118  | 10.8 | 53                                  | 117  | 10.3 |
|      | 19 | 51                                  | 111  | 9.9  | 49                              | 110  | 9.5  | 46                                  | 108  | 9.1  |
| 2100 | 25 | 71                                  | 129  | 13.5 | 68                              | 129  | 12.9 | 64                                  | 129  | 12.2 |
|      | 23 | 64                                  | 123  | 12.1 | 60                              | 123  | 11.5 | 57                                  | 122  | 11.0 |
|      | 21 | 56                                  | 116  | 10.7 | 53                              | 115  | 10.3 | 50                                  | 114  | 9.8  |
|      | 19 | 48                                  | 108  | 9.5  | 46                              | 106  | 9.1  | 43                                  | 104  | 8.7  |
|      | 17 | 41                                  | 97   | 8.2  | 39                              | 95   | 7.8  | 37                                  | 91   | 7.5  |

## Aircraft Performance Charts

- Published in our POH/AFM
- Based on a new airplane, engine, and propeller
- Based on a test pilot flying with excellent technique (airspeed control, proper leaning)
- Formatted in a variety of ways
  - Some use pressure altitude + temperature (Cessnas)
  - Some use density altitude only

# Takeoff Distance - Temperature

## TAKEOFF DISTANCE MAXIMUM WEIGHT 3100 LBS

### CONDITIONS:

Flaps 20°

2400 RPM and 31 Inches Hg Prior to Brake Release

Mixture Full Rich

Cowl Flaps Open

Paved, Level, Dry Runway

Zero Wind

**SHORT FIELD**

### 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 15% of the "ground roll" figure.

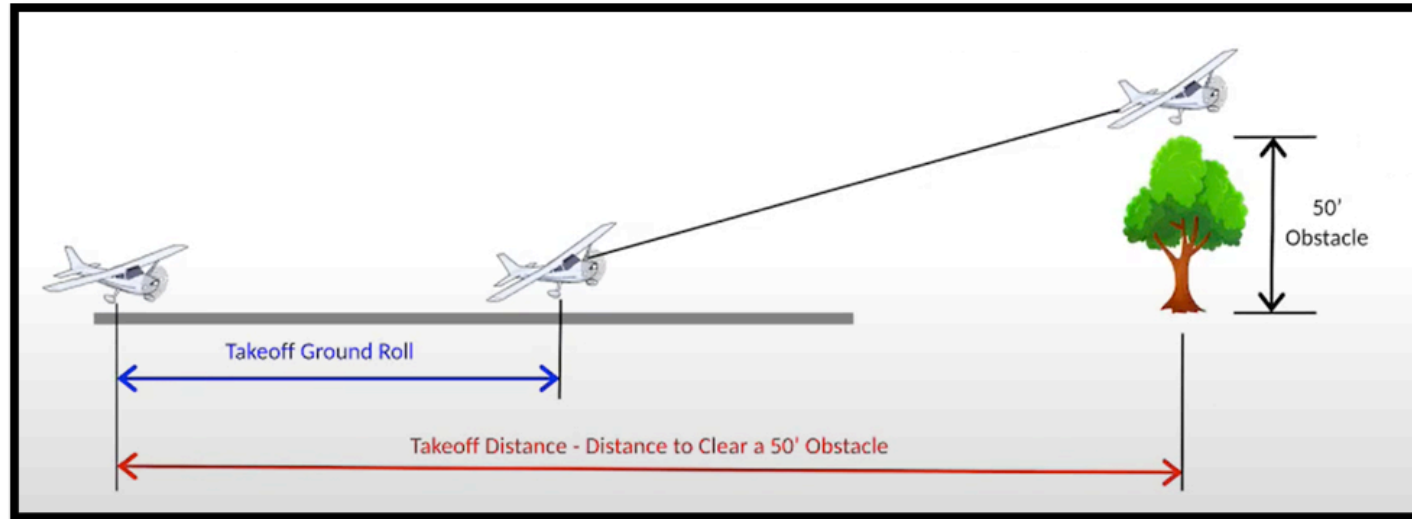
| WEIGHT<br>LBS | TAKEOFF<br>SPEED<br>KIAS |             | PRESS<br>ALT<br>FT | 32°F<br>0°C  |                                | 50°F<br>10°C |                                | 68°F<br>20°C |                                | 86°F<br>30°C |                                | 104°F<br>40°C |                                |
|---------------|--------------------------|-------------|--------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|---------------|--------------------------------|
|               | LIFT<br>OFF              | AT<br>50 FT |                    | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL  | TOTAL<br>TO CLEAR<br>50 FT OBS |
| 3100          | 49                       | 58          | S.L.               | 700          | 1310                           | 760          | 1415                           | 820          | 1535                           | 890          | 1665                           | 960           | 1805                           |
|               |                          |             | 1000               | 750          | 1390                           | 810          | 1505                           | 880          | 1630                           | 950          | 1770                           | 1025          | 1925                           |
|               |                          |             | 2000               | 800          | 1475                           | 870          | 1600                           | 940          | 1735                           | 1015         | 1885                           | 1100          | 2050                           |
|               |                          |             | 3000               | 855          | 1570                           | 930          | 1700                           | 1005         | 1850                           | 1090         | 2010                           | 1175          | 2190                           |
|               |                          |             | 4000               | 920          | 1670                           | 995          | 1815                           | 1080         | 1970                           | 1165         | 2145                           | 1260          | 2345                           |
|               |                          |             | 5000               | 985          | 1780                           | 1070         | 1935                           | 1155         | 2110                           | 1250         | 2300                           | 1355          | 2510                           |
|               |                          |             | 6000               | 1055         | 1900                           | 1145         | 2070                           | 1245         | 2260                           | 1345         | 2465                           | 1455          | 2700                           |
|               |                          |             | 7000               | 1135         | 2035                           | 1235         | 2220                           | 1335         | 2425                           | 1450         | 2650                           | 1565          | 2910                           |
|               |                          |             | 8000               | 1220         | 2180                           | 1325         | 2385                           | 1440         | 2605                           | 1560         | 2855                           | 1685          | 3140                           |

## Ground Roll

- S.L. at 0° C: 700'
- S.L. at 40° C: 960'
- **260 ft.** increase from temperature alone



# Takeoff Distance - Ground Roll vs Obstacle Clearance



# Takeoff Distance - Wind

## TAKEOFF DISTANCE MAXIMUM WEIGHT 3100 LBS

### CONDITIONS:

Flaps 20°  
2400 RPM and 31 Inches Hg Prior to Brake Release  
Mixture Full Rich  
Cowl Flaps Open  
Paved, Level, Dry Runway  
Zero Wind

**SHORT FIELD**

### 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 15% of the "ground roll" figure.

| WEIGHT<br>LBS | TAKEOFF<br>SPEED<br>KIAS |             | PRESS<br>ALT<br>FT | 32°F<br>0°C  |                                | 50°F<br>10°C |                                | 68°F<br>20°C |                                | 86°F<br>30°C ✓ |                                | 104°F<br>40°C |                                |
|---------------|--------------------------|-------------|--------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|----------------|--------------------------------|---------------|--------------------------------|
|               | LIFT<br>OFF              | AT<br>50 FT |                    | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL   | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL  | TOTAL<br>TO CLEAR<br>50 FT OBS |
|               |                          |             |                    |              |                                |              |                                |              |                                |                |                                |               |                                |
| 3100          | 49                       | 58          | S.L.               | 700          | 1310                           | 760          | 1415                           | 820          | 1535                           | 890            | 1665                           | 960           | 1805                           |
|               |                          |             | 1000               | 750          | 1390                           | 810          | 1505                           | 880          | 1630                           | 950            | 1770                           | 1025          | 1925                           |
|               |                          |             | 2000               | 800          | 1475                           | 870          | 1600                           | 940          | 1735                           | 1015           | 1885                           | 1100          | 2050                           |
|               |                          |             | 3000               | 855          | 1570                           | 930          | 1700                           | 1005         | 1850                           | 1090           | 2010                           | 1175          | 2190                           |
|               |                          |             | 4000               | 920          | 1670                           | 995          | 1815                           | 1080         | 1970                           | 1165           | 2145                           | 1260          | 2345                           |
|               |                          |             | 5000               | 985          | 1780                           | 1070         | 1935                           | 1155         | 2110                           | 1250           | 2300                           | 1355          | 2510                           |
|               |                          |             | 6000               | 1055         | 1900                           | 1145         | 2070                           | 1245         | 2260                           | 1345           | 2465                           | 1455          | 2700                           |
|               |                          |             | 7000               | 1135         | 2035                           | 1235         | 2220                           | 1335         | 2425                           | 1450           | 2650                           | 1565          | 2910                           |
|               |                          |             | 8000               | 1220         | 2180                           | 1325         | 2385                           | 1440         | 2605                           | 1560           | 2855                           | 1685          | 3140                           |

Sea level, 20°C

18 knot headwind:  
20% decrease  
 $820 * 0.8 = 656 \text{ ft.}$

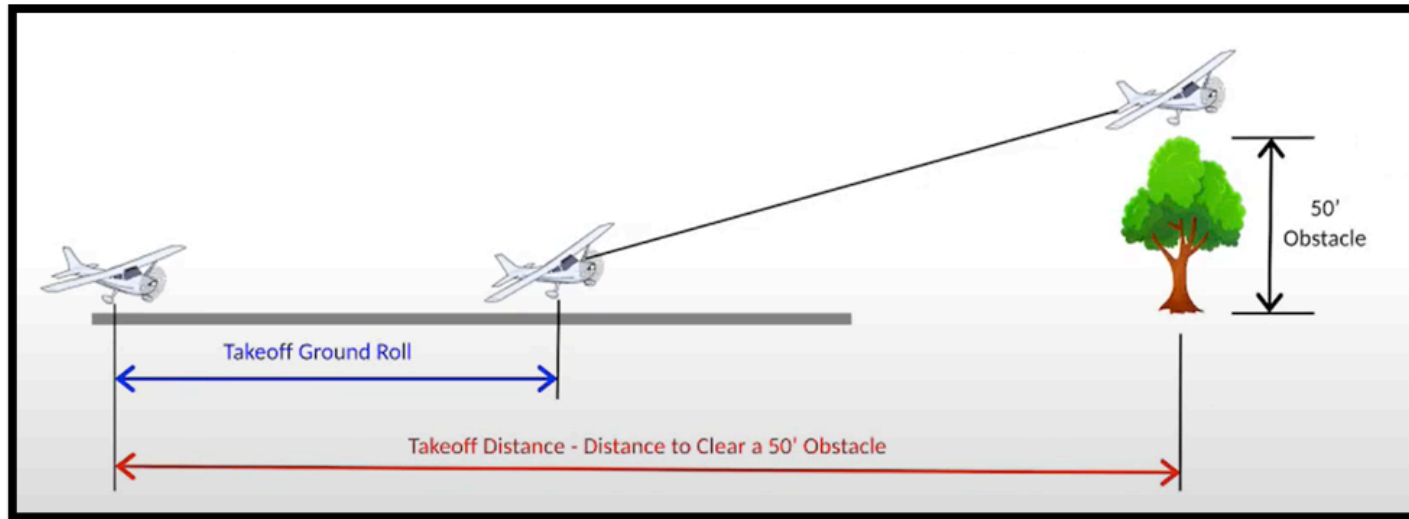
4 knot tailwind:  
20% increase  
 $820 * 1.2 = 984 \text{ ft.}$



# Realistic Performance

- Takeoff performance
  - New engine, new propeller
  - Test pilot with excellent technique
- Landing performance
  - Excellent technique, energy management
  - No gusty winds, or gust factor
  - Maximum braking
- A safety factor helps in managing this discrepancy
  - We'll use a safety factor of **+50%** for takeoff and landing

## Takeoff Distance - Safety Factor



Ground roll = **820 ft.**

Over 50' obstacle = **1535 ft.**

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With 50% safety factor:

$820 * 1.5 = \mathbf{1230 \text{ ft.}}$

$1535 * 1.5 = \mathbf{2302 \text{ ft.}}$

# Time, Distance, Fuel to Climb (Normal Climb) - Altitude

## TIME, FUEL, AND DISTANCE TO CLIMB

NORMAL CLIMB - 95 KIAS

CONDITIONS:

Flaps Up  
2400 RPM  
24 Inches Hg  
Mixture Full Rich  
Cowl Flaps Open  
Standard Temperature

NOTES:

- 1. Add 2.0 gallons of fuel for engine start, taxi and takeoff allowance.
- 2. Increase time, fuel and distance by 10% for each 7°C above standard temperature.
- 3. Distances shown are based on zero wind.

| WEIGHT<br>LBS | PRESSURE<br>ALTITUDE<br>FT | TEMP<br>°C | RATE OF<br>CLIMB<br>FPM | FROM SEA LEVEL |                      |                |
|---------------|----------------------------|------------|-------------------------|----------------|----------------------|----------------|
|               |                            |            |                         | TIME<br>MIN    | FUEL USED<br>GALLONS | DISTANCE<br>NM |
| 3100          | S.L.                       | 15         | 500                     | 0              | 0                    | 0              |
|               | 2000                       | 11         | 500                     | 4              | 1.4                  | 6              |
|               | 4000                       | 7          | 495                     | 8              | 2.8                  | 13             |
|               | 6000                       | 3          | 485                     | 12             | 4.3                  | 20             |
|               | 8000                       | -1         | 470                     | 16             | 5.7                  | 27             |
|               | 10,000                     | -5         | 450                     | 21             | 7.3                  | 35             |

Airport: 4000'

Cruise: 8000'

16 - 8 = 8 minutes

5.7 - 2.8 = 2.9 gallons

27 - 13 = 14nm

Climb rate decreases as we ascend

# Time, Distance, Fuel to Climb (Normal Climb) - Temperature

## TIME, FUEL, AND DISTANCE TO CLIMB

### NORMAL CLIMB - 95 KIAS

#### CONDITIONS:

Flaps Up  
2400 RPM  
24 Inches Hg  
Mixture Full Rich  
Cowl Flaps Open  
Standard Temperature

#### NOTES:

1. Add 2.0 gallons of fuel for engine start, taxi and takeoff allowance.
2. Increase time, fuel and distance by 10% for each 7°C above standard temperature.
3. Distances shown are based on zero wind.

| WEIGHT<br>LBS | PRESSURE<br>ALTITUDE<br>FT | TEMP<br>°C | RATE OF<br>CLIMB<br>FPM | FROM SEA LEVEL |                      |                |
|---------------|----------------------------|------------|-------------------------|----------------|----------------------|----------------|
|               |                            |            |                         | TIME<br>MIN    | FUEL USED<br>GALLONS | DISTANCE<br>NM |
| 3100          | S.L.                       | 15         | 500                     | 0              | 0                    | 0              |
|               | 2000                       | 11         | 500                     | 4              | 1.4                  | 6              |
|               | 4000                       | 7          | 495                     | 8              | 2.8                  | 13             |
|               | 6000                       | 3          | 485                     | 12             | 4.3                  | 20             |
|               | 8000                       | -1         | 470                     | 16             | 5.7                  | 27             |
|               | 10,000                     | -5         | 450                     | 21             | 7.3                  | 35             |
|               | 12,000                     | -9         | 425                     | 25             | 8.9                  | 44             |

8 minutes, 2.9 gallons, 14nm

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14°C above standard

20% increase

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$8 * 1.2 = 9.6$  minutes

$2.9 * 1.2 = 3.5$  gallons

$14 * 1.2 = 16.8$ nm

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+2 gal start/taxi/takeoff

$3.5 + 2 = 5.5$  gallons

# Cruise Performance - Altitude and Temperature

## CRUISE PERFORMANCE

PRESSURE ALTITUDE 2000 FEET

### CONDITIONS:

3100 Pounds  
Recommended Lean Mixture  
Cowl Flaps Closed

### NOTE

For best fuel economy, operate at the leanest mixture that results in smooth engine operation or at peak EGT.

|      |    | 20°C BELOW<br>STANDARD TEMP<br>-9°C |      |      | STANDARD<br>TEMPERATURE<br>11°C |      |      | 20°C ABOVE<br>STANDARD TEMP<br>31°C |      |      |
|------|----|-------------------------------------|------|------|---------------------------------|------|------|-------------------------------------|------|------|
| RPM  | MP | %<br>BHP                            | KTAS | GPH  | %<br>BHP                        | KTAS | GPH  | %<br>BHP                            | KTAS | GPH  |
| 2400 | 25 | ---                                 | ---  | ---  | 78                              | 137  | 14.8 | 74                                  | 137  | 14.0 |
|      | 23 | 74                                  | 131  | 14.0 | 70                              | 131  | 13.3 | 66                                  | 130  | 12.6 |
|      | 21 | 65                                  | 125  | 12.4 | 62                              | 124  | 11.8 | 59                                  | 123  | 11.3 |
|      | 19 | 57                                  | 117  | 10.9 | 54                              | 116  | 10.5 | 51                                  | 115  | 10.0 |
| 2300 | 25 | 78                                  | 135  | 14.9 | 74                              | 135  | 14.1 | 71                                  | 134  | 13.4 |
|      | 23 | 70                                  | 129  | 13.3 | 67                              | 128  | 12.7 | 63                                  | 128  | 12.1 |
|      | 21 | 62                                  | 122  | 11.8 | 59                              | 121  | 11.3 | 56                                  | 120  | 10.8 |
|      | 19 | 54                                  | 114  | 10.4 | 51                              | 113  | 10.0 | 49                                  | 112  | 9.6  |
| 2200 | 25 | 75                                  | 132  | 14.2 | 71                              | 132  | 13.5 | 67                                  | 131  | 12.8 |
|      | 23 | 67                                  | 126  | 12.7 | 64                              | 126  | 12.1 | 60                                  | 125  | 11.5 |
|      | 21 | 59                                  | 119  | 11.3 | 56                              | 118  | 10.8 | 53                                  | 117  | 10.3 |
|      | 19 | 51                                  | 111  | 9.9  | 49                              | 110  | 9.5  | 46                                  | 108  | 9.1  |
| 2100 | 25 | 71                                  | 129  | 13.5 | 68                              | 129  | 12.9 | 64                                  | 129  | 12.2 |
|      | 23 | 64                                  | 123  | 12.1 | 60                              | 123  | 11.5 | 57                                  | 122  | 11.0 |
|      | 21 | 56                                  | 116  | 10.7 | 53                              | 115  | 10.3 | 50                                  | 114  | 9.8  |
|      | 19 | 48                                  | 108  | 9.5  | 46                              | 106  | 9.1  | 43                                  | 104  | 8.7  |

## CRUISE PERFORMANCE

PRESSURE ALTITUDE 10,000 FEET

### CONDITIONS:

3100 Pounds  
Recommended Lean Mixture  
Cowl Flaps Closed

### NOTE

For best fuel economy, operate at the leanest mixture that results in smooth engine operation or at peak EGT.

|      |    | 20°C BELOW<br>STANDARD TEMP<br>-25°C |      |      | STANDARD<br>TEMPERATURE<br>-5°C |      |      | 20°C ABOVE<br>STANDARD TEMP<br>15°C |      |      |
|------|----|--------------------------------------|------|------|---------------------------------|------|------|-------------------------------------|------|------|
| RPM  | MP | %<br>BHP                             | KTAS | GPH  | %<br>BHP                        | KTAS | GPH  | %<br>BHP                            | KTAS | GPH  |
| 2400 | 25 | ---                                  | ---  | ---  | 79                              | 148  | 15.1 | 75                                  | 148  | 14.3 |
|      | 23 | 76                                   | 143  | 14.5 | 72                              | 142  | 13.8 | 69                                  | 142  | 13.1 |
|      | 21 | 69                                   | 136  | 13.1 | 66                              | 136  | 12.5 | 62                                  | 135  | 11.9 |
|      | 19 | 62                                   | 129  | 11.7 | 59                              | 128  | 11.2 | 56                                  | 127  | 10.7 |
| 2300 | 25 | 80                                   | 146  | 15.2 | 76                              | 146  | 14.5 | 72                                  | 145  | 13.7 |
|      | 23 | 73                                   | 140  | 13.9 | 70                              | 140  | 13.2 | 66                                  | 139  | 12.5 |
|      | 21 | 66                                   | 134  | 12.5 | 63                              | 133  | 12.0 | 60                                  | 132  | 11.4 |
|      | 19 | 59                                   | 126  | 11.3 | 56                              | 125  | 10.8 | 53                                  | 124  | 10.3 |
| 2200 | 25 | 77                                   | 143  | 14.6 | 73                              | 143  | 13.9 | 69                                  | 142  | 13.2 |
|      | 23 | 70                                   | 137  | 13.3 | 67                              | 137  | 12.7 | 63                                  | 136  | 12.0 |
|      | 21 | 63                                   | 131  | 12.0 | 60                              | 130  | 11.5 | 57                                  | 129  | 10.9 |
|      | 19 | 56                                   | 123  | 10.8 | 53                              | 122  | 10.3 | 51                                  | 120  | 9.9  |
| 2100 | 25 | 74                                   | 140  | 14.0 | 70                              | 140  | 13.3 | 66                                  | 139  | 12.6 |
|      | 23 | 67                                   | 135  | 12.7 | 64                              | 134  | 12.1 | 60                                  | 133  | 11.5 |
|      | 21 | 60                                   | 128  | 11.5 | 57                              | 127  | 11.0 | 54                                  | 125  | 10.5 |
|      | 19 | 53                                   | 120  | 10.4 | 51                              | 119  | 9.9  | 48                                  | 116  | 9.5  |



# RANGE PROFILE

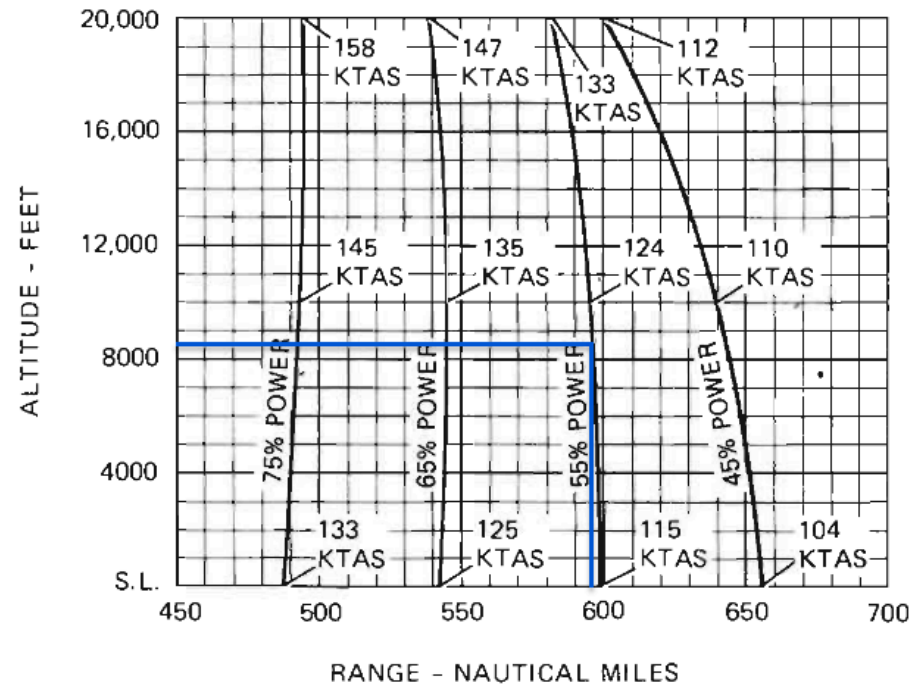
45 MINUTES RESERVE  
65 GALLONS USABLE FUEL

## CONDITIONS:

3100 Pounds  
Recommended Lean Mixture for Cruise  
Standard Temperature  
Zero Wind

## NOTE:

This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the distance during a normal climb up to 12,000 feet and maximum climb above 12,000 feet.



# ENDURANCE PROFILE

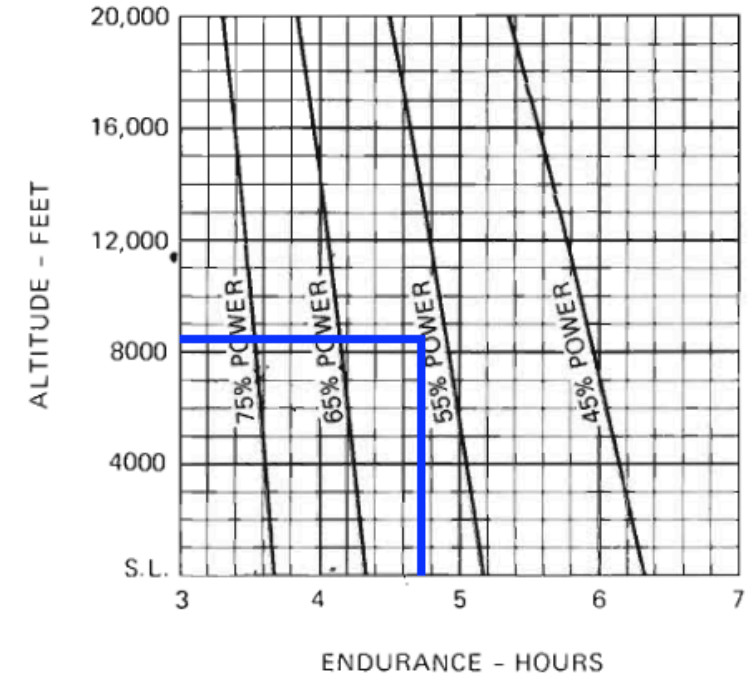
45 MINUTES RESERVE  
65 GALLONS USABLE FUEL

## CONDITIONS:

3100 Pounds  
Recommended Lean Mixture for Cruise  
Standard Temperature

## NOTE:

This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the time during a normal climb up to 12,000 feet and maximum climb above 12,000 feet.



# Landing Distance (Short Field)

## LANDING DISTANCE

### SHORT FIELD

CONDITIONS:  
Flaps FULL  
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 40% of the "ground roll" figure.
  - 4. If a landing with flaps up is necessary, increase the approach speed by 9 KIAS and allow for 40% longer distances.

| WEIGHT<br>LBS | SPEED<br>AT<br>50 FT<br>KIAS | PRESS<br>ALT<br>FT | 0°C          |                                | 10°C         |                                | 20°C         |                                | 30°C         |                                | 40°C         |                                |
|---------------|------------------------------|--------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|
|               |                              |                    | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS |
| 2950          | 61                           | S.L.               | 560          | 1300                           | 580          | 1335                           | 600          | 1365                           | 620          | 1400                           | 640          | 1435                           |
|               |                              | 1000               | 580          | 1335                           | 600          | 1365                           | 620          | 1400                           | 645          | 1440                           | 665          | 1475                           |
|               |                              | 2000               | 600          | 1370                           | 625          | 1405                           | 645          | 1440                           | 670          | 1480                           | 690          | 1515                           |
|               |                              | 3000               | 625          | 1410                           | 645          | 1445                           | 670          | 1485                           | 695          | 1525                           | 715          | 1560                           |
|               |                              | 4000               | 650          | 1450                           | 670          | 1485                           | 695          | 1525                           | 720          | 1565                           | 740          | 1600                           |
|               |                              | 5000               | 670          | 1485                           | 695          | 1525                           | 720          | 1565                           | 745          | 1610                           | 770          | 1650                           |
|               |                              | 6000               | 700          | 1530                           | 725          | 1575                           | 750          | 1615                           | 775          | 1660                           | 800          | 1700                           |
|               |                              | 7000               | 725          | 1575                           | 750          | 1615                           | 780          | 1665                           | 805          | 1710                           | 830          | 1750                           |
|               |                              | 8000               | 755          | 1625                           | 780          | 1665                           | 810          | 1715                           | 835          | 1760                           | 865          | 1805                           |

Headwind: 9 knots

Pressure altitude: S.L.

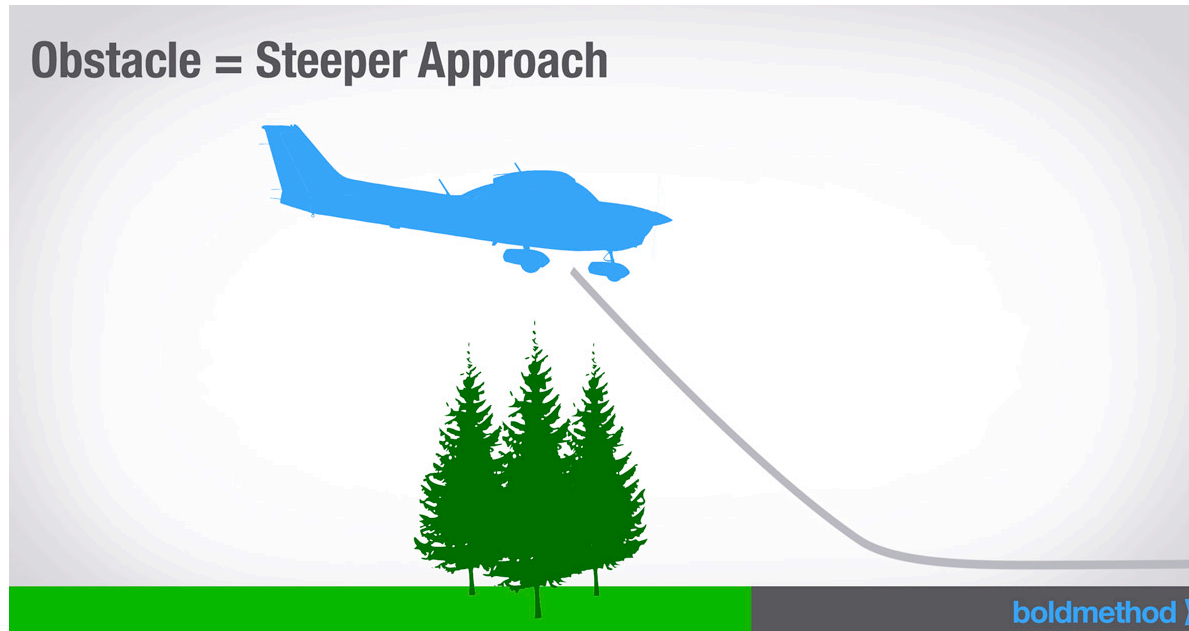
Temperature: 20°C

Decrease distances 10%

$0.9 * 600 = 540 \text{ ft. ground roll}$

$0.9 * 1365 = 1231 \text{ ft. over 50' obs.}$

# Landing Distance (Short Field) - Safety Factor



540 ft. ground roll  
1231 ft. over 50' obs.

---

Ground roll:

$$540 * 1.5 = \mathbf{810 \text{ ft}}$$

Over 50' obstacle:

$$1231 * 1.5 = \mathbf{1846 \text{ ft}}$$

# FLAPS 25° TAKEOFF GROUND ROLL

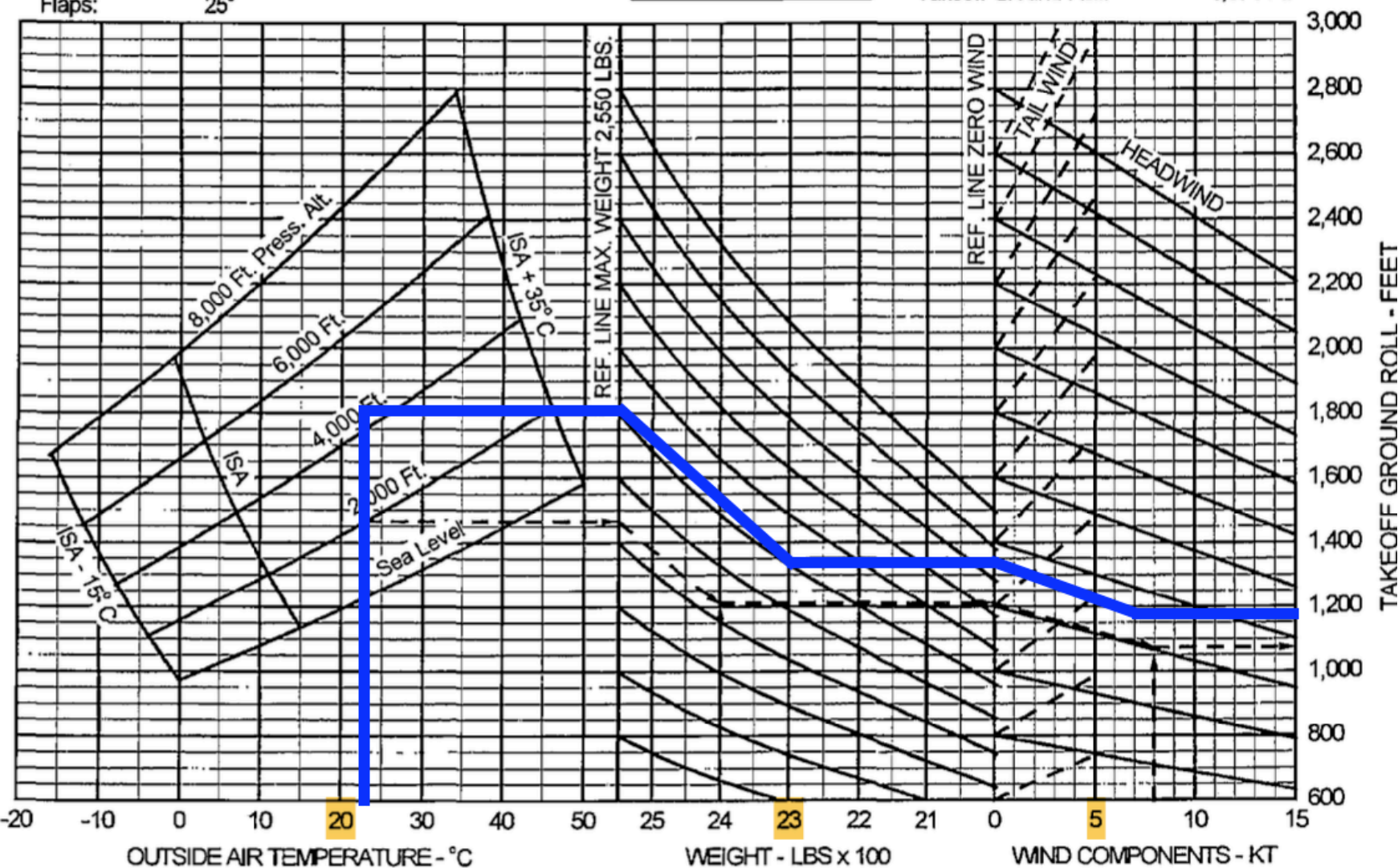
## ASSOCIATED CONDITIONS

Power: FULL THROTTLE BEFORE BRAKE RELEASE  
 Air Conditioner: OFF  
 Runway: PAVED, LEVEL, & DRY  
 Airspeed: REFER TO TABLE AT RIGHT  
 Propeller: SENSENICH 76EM8S14-0-62  
 Flaps: 25°

| TAKEOFF SPEEDS KIAS |         |
|---------------------|---------|
| WT                  | LIFTOFF |
| 2,550               | 55      |
| 2,450               | 55      |
| 2,350               | 53      |
| 2,250               | 50      |

## EXAMPLE

Depart Airport Pressure Alt: 2,000 Ft.  
 Temperature: 23° C  
 Gross Weight: 2,400 Lb.  
 Headwind: 8 Kt.  
 Takeoff Ground Roll: 1,071 Ft.



4100' press.  
 altitude  
 22° C  
 2300 lbs.  
 7 knots headwind  
**~1150 ft.**

# Differences between Actual and Estimated Performance



- Conditions are different from forecast
- Pilot technique
  - Takeoff
  - Landing
  - Engine leaning
- Age of engine, propeller, airframe
- Runway slope: Up or down
- Wet runway: Braking action

# Limitations



# Where do we find limitations?

CESSNA  
MODEL T182

SECTION 2  
LIMITATIONS

## SECTION 2 LIMITATIONS

- POH limitations section
- Placards and markings
- Performance charts

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# Engine Limitations

## POWER PLANT LIMITATIONS

Engine Manufacturer: Avco Lycoming.

Engine Model Number: O-540-L3C5D.

Maximum Power: 235 BHP rating.

Engine Operating Limits for Takeoff and Continuous Operations:

Maximum Engine Speed: 2400 RPM.

Maximum Manifold Pressure: 31 in. Hg.

Maximum Cylinder Head Temperature: 500°F (260°C).

Maximum Oil Temperature: 245°F (118°C).

Oil Pressure, Minimum: 25 psi.

Maximum: 115 psi.

Fuel Pressure, Minimum: 3.0 psi.

Maximum: 30.0 psi.

Fuel Grade: See Fuel Limitations.

Oil Grade (Specification):

MIL-L-6082 Aviation Grade Straight Mineral Oil or MIL-L-22851

Ashless Dispersant Oil.

# Airspeed Limitations

|                 | SPEED                                                            | KCAS             | KIAS             | REMARKS                                                                    |
|-----------------|------------------------------------------------------------------|------------------|------------------|----------------------------------------------------------------------------|
| V <sub>NE</sub> | Never Exceed Speed                                               | 175              | 178              | Do not exceed this speed in any operation.                                 |
| V <sub>NO</sub> | Maximum Structural Cruising Speed                                | 138              | 140              | Do not exceed this speed except in smooth air, and then only with caution. |
| V <sub>A</sub>  | Maneuvering Speed:<br>3100 Pounds<br>2600 Pounds<br>2100 Pounds  | 110<br>100<br>90 | 111<br>101<br>90 | Do not make full or abrupt control movements above this speed.             |
| V <sub>FE</sub> | Maximum Flap Extended Speed:<br>To 10° Flaps<br>10° - FULL Flaps | 138<br>95        | 140<br>95        | Do not exceed these speeds with the given flap settings.                   |
|                 | Maximum Window Open Speed                                        | 175              | 178              | Do not exceed this speed with windows open.                                |



# Load Factor Limits

## FLIGHT LOAD FACTOR LIMITS

Flight Load Factors:

- \*Flaps Up: +3.8g, -1.52g

- \*Flaps Down: +2.0g

- \*The design load factors are 150% of the above, and in all cases, the structure meets or exceeds design loads.

# Operating Limits

## MAXIMUM OPERATING ALTITUDE LIMIT

Certificated Maximum Operating Altitude: 20,000 Ft.

## OTHER LIMITATIONS

### FLAP LIMITATIONS

Approved Takeoff Range: 0° to 20°.

Approved Landing Range: 0° to FULL.

-----  
Maximum Demonstrated Crosswind Velocity:

Takeoff or Landing . . . . . 15 KNOTS

# High Temperatures

Is it advisable to fly when it's > 40°C?

## TAKEOFF DISTANCE

MAXIMUM WEIGHT 3100 LBS

CONDITIONS:

Flaps 20°

2400 RPM and 31 Inches Hg Prior to Brake Release

Mixture Full Rich

Cowl Flaps Open

Paved, Level, Dry Runway

Zero Wind

**SHORT FIELD**

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 15% of the "ground roll" figure.

| WEIGHT<br>LBS | TAKEOFF<br>SPEED<br>KIAS |             | PRESS<br>ALT<br>FT | 32°F<br>0°C  |                                | 50°F<br>10°C |                                | 68°F<br>20°C |                                | 86°F<br>30°C |                                | 104°F<br>40°C |                                |
|---------------|--------------------------|-------------|--------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|--------------|--------------------------------|---------------|--------------------------------|
|               | LIFT<br>OFF              | AT<br>50 FT |                    | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL | TOTAL<br>TO CLEAR<br>50 FT OBS | GRND<br>ROLL  | TOTAL<br>TO CLEAR<br>50 FT OBS |
|               |                          |             |                    |              |                                |              |                                |              |                                |              |                                |               |                                |
| 3100          | 49                       | 58          | S.L.               | 700          | 1310                           | 760          | 1415                           | 820          | 1535                           | 890          | 1665                           | 960           | 1805                           |
|               |                          |             | 1000               | 750          | 1390                           | 810          | 1505                           | 880          | 1630                           | 950          | 1770                           | 1025          | 1925                           |
|               |                          |             | 2000               | 800          | 1475                           | 870          | 1600                           | 940          | 1735                           | 1015         | 1885                           | 1100          | 2050                           |
|               |                          |             | 3000               | 855          | 1570                           | 930          | 1700                           | 1005         | 1850                           | 1090         | 2010                           | 1175          | 2190                           |
|               |                          |             | 4000               | 920          | 1670                           | 995          | 1815                           | 1080         | 1970                           | 1165         | 2145                           | 1260          | 2345                           |
|               |                          |             | 5000               | 985          | 1780                           | 1070         | 1935                           | 1155         | 2110                           | 1250         | 2300                           | 1355          | 2510                           |
|               |                          |             | 6000               | 1055         | 1900                           | 1145         | 2070                           | 1245         | 2260                           | 1345         | 2465                           | 1455          | 2700                           |
|               |                          |             | 7000               | 1135         | 2035                           | 1235         | 2220                           | 1335         | 2425                           | 1450         | 2650                           | 1565          | 2910                           |
|               |                          |             | 8000               | 1220         | 2180                           | 1325         | 2385                           | 1440         | 2605                           | 1560         | 2855                           | 1685          | 3140                           |

# Summary

- Performance concepts
  - Air and density
  - International Standard Atmosphere
  - Types of Altitude
  - Types of Airspeed
  - How density affects performance
- Airplane performance charts
  - Computing performance values using Cessna charts
- Airplane limitations