# 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

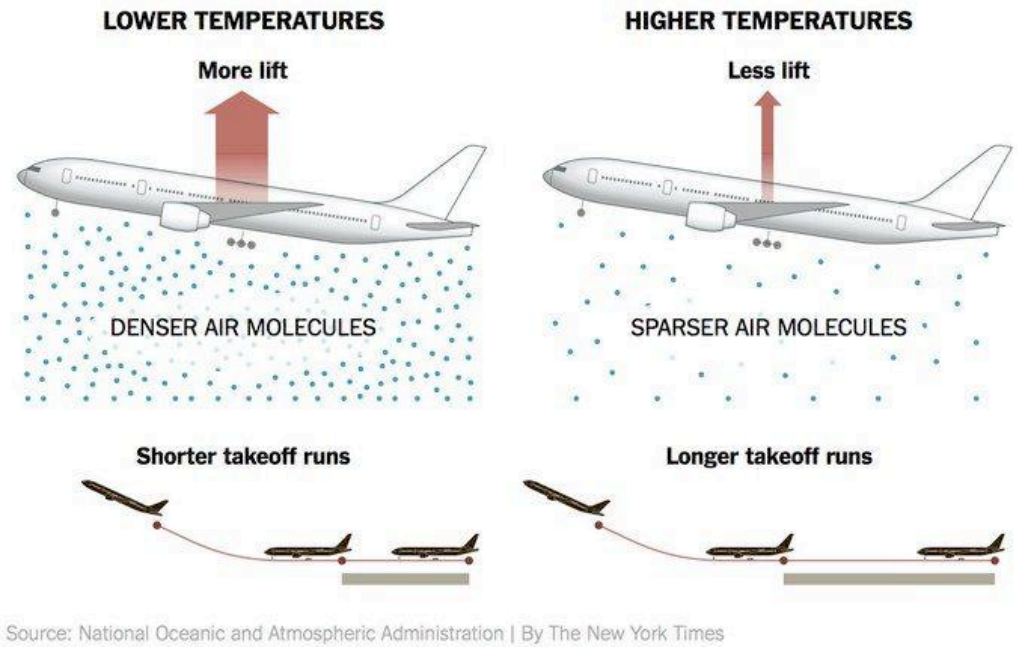
# Overview

- 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

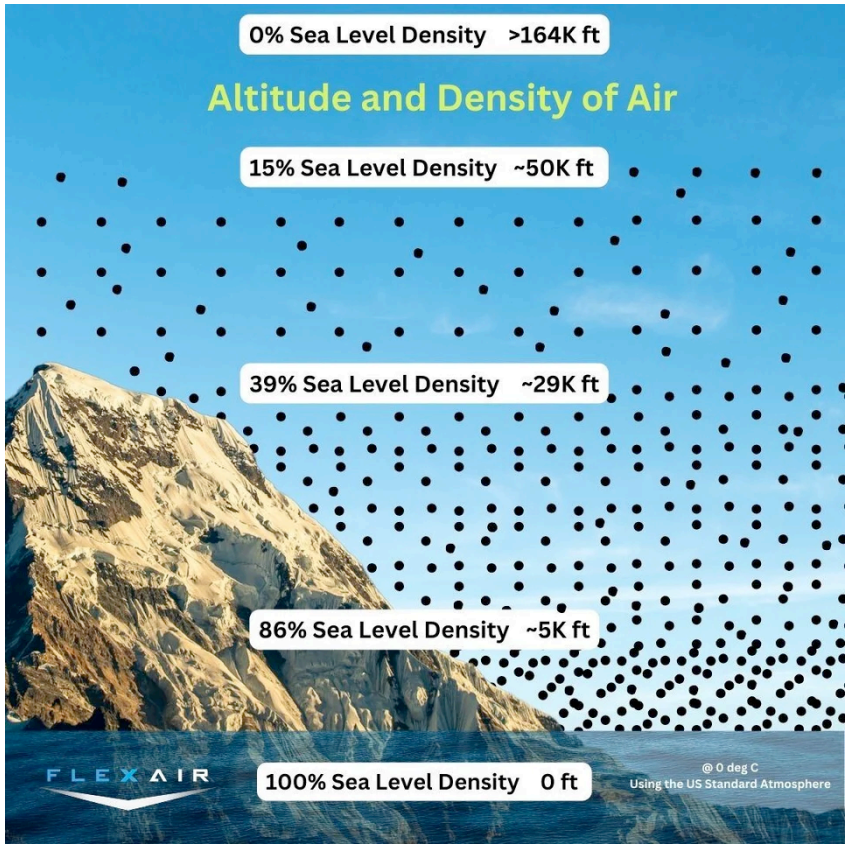
- Our airplane swims through the air, air molecules bounce off the airplane
  - As these air molecules are deflected downward, our airplane is forced upward
  - Our propeller pushes air backwards which pushes us forwards
  - Our engine "breaths" air from outside, burns that air with fuel to produce power




# High and Low Air Density

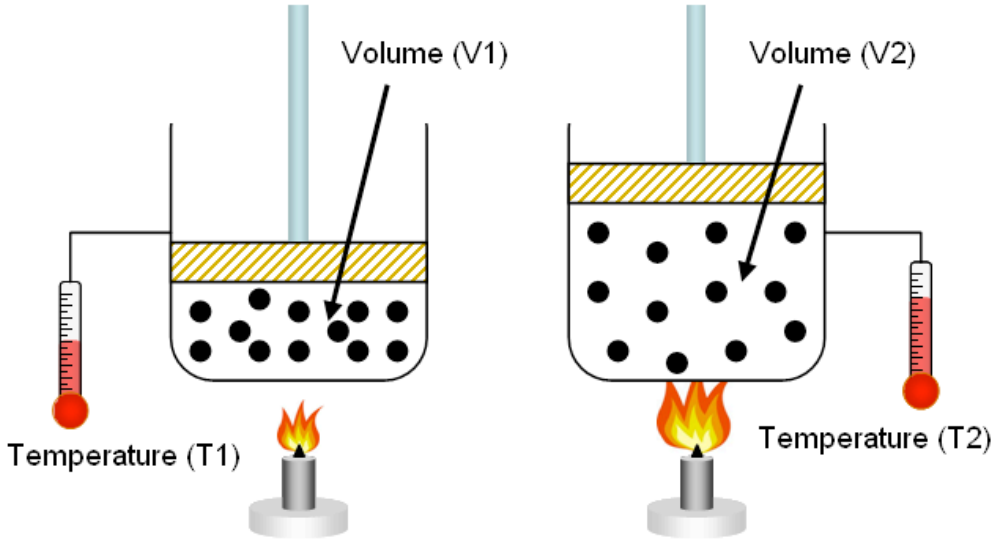
- All of this depends on how close the air molecules are together
- Tightly spaced = more air to grab on to
  - Wings can produce more lift
  - Propeller can produce more thrust
  - Engines can produce more power
- Density constantly changes with
  i. Pressure
  ii. Temperature
  iii. Humidity

# 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

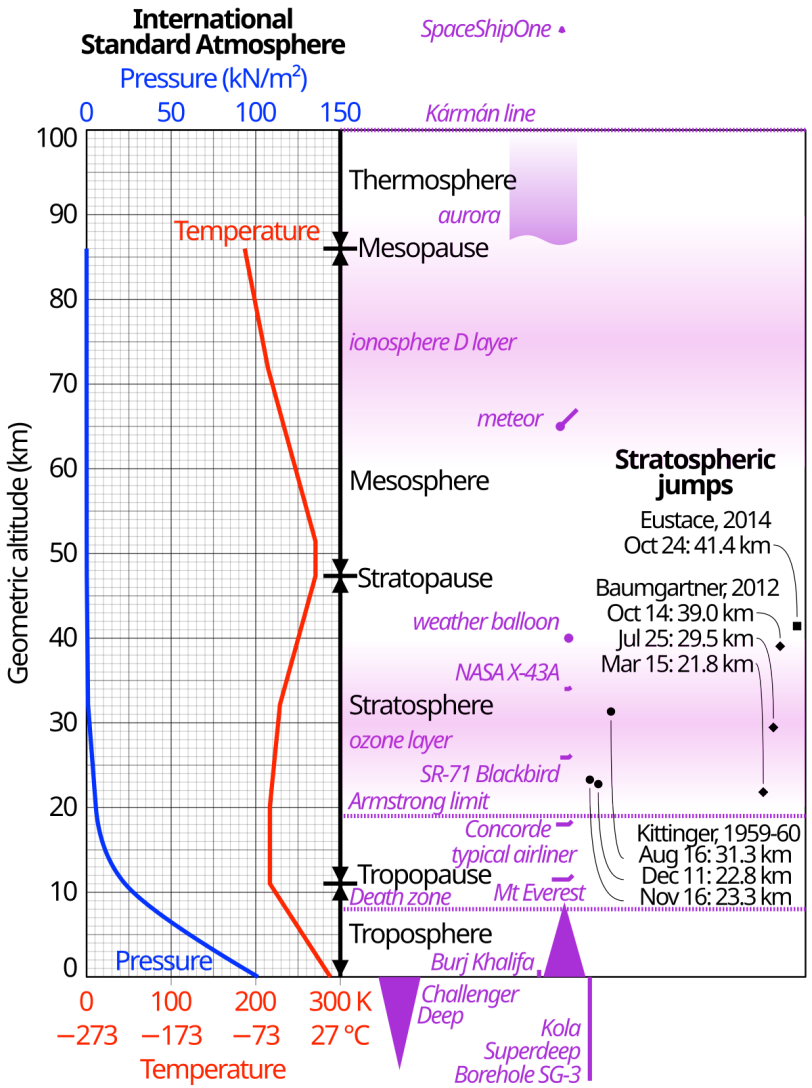
# Humidity: Temperature (Variable #3)

- 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 chats 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

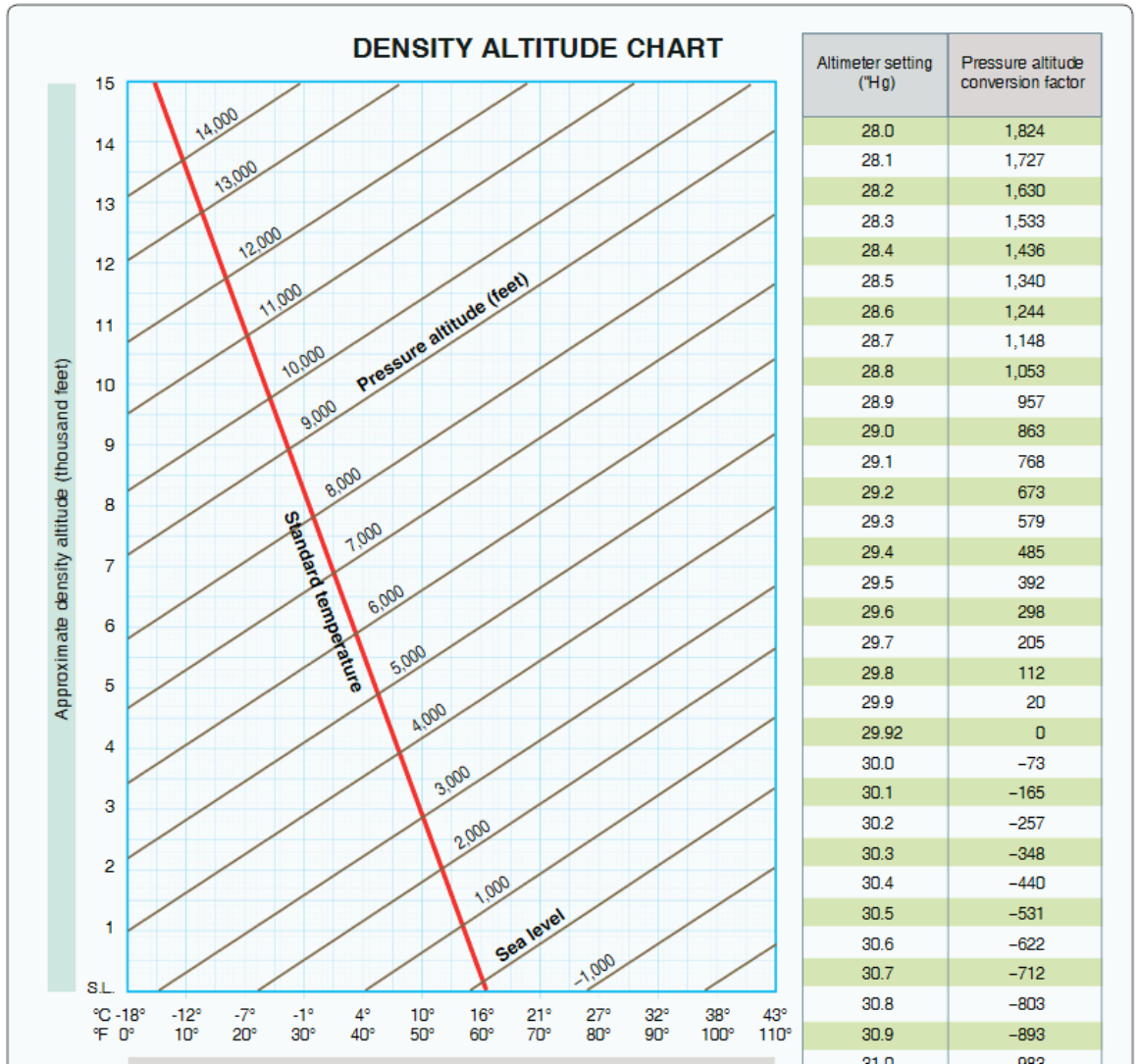
# International Standard Atmosphere (ISA)




- What if we made a fake atmosphere with known conditions?
  - Density can 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




| Altimeter setting ("Hg) | Pressure altitude conversion factor |
|---|---|
| 28.0 | 1,824 |
| 28.1 | 1,727 |
| 28.2 | 1,630 |
| 28.3 | 1,533 |
| 28.4 | 1,436 |
| 28.5 | 1,340 |
| 28.6 | 1,244 |
| 28.7 | 1,148 |
| 28.8 | 1,053 |
| 28.9 | 957 |
| 29.0 | 863 |
| 29.1 | 768 |
| 29.2 | 673 |
| 29.3 | 579 |
| 29.4 | 485 |
| 29.5 | 392 |
| 29.6 | 298 |
| 29.7 | 205 |
| 29.8 | 112 |
| 29.9 | 20 |
| 29.92 | 0 |
| 30.0 | –73 |
| 30.1 | –165 |
| 30.2 | –257 |
| 30.3 | –348 |
| 30.4 | –440 |
| 30.5 | –531 |
| 30.6 | –622 |
| 30.7 | –712 |
| 30.8 | –803 |
| 30.9 | –893 |

**4000 ft. / 84° F, 29° C / 29.80" Hg**

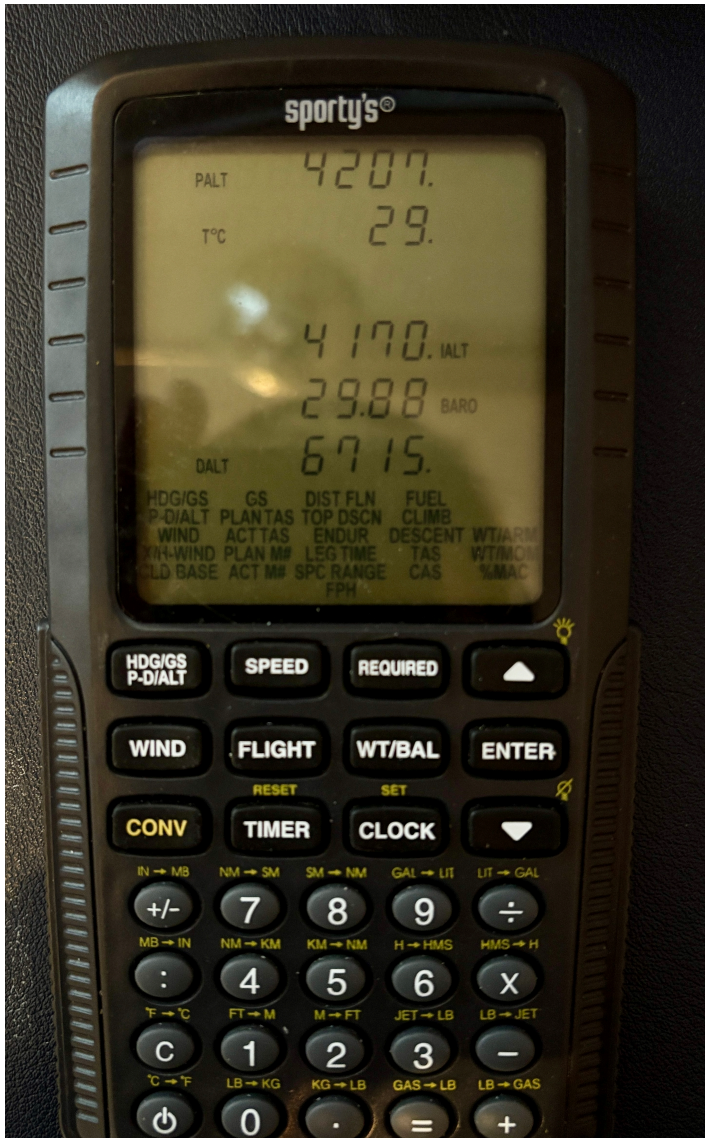
1. Start with field elevation: **4000 ft.**
2. Correct for Variable Ambient Pressure
   - 4000 + 112' = **4112**
   - *Pressure altitude*
3. Correct for Variable Temperature:
   - 4000' line & **29° F**
   - ~6700' *density altitude*

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 in 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

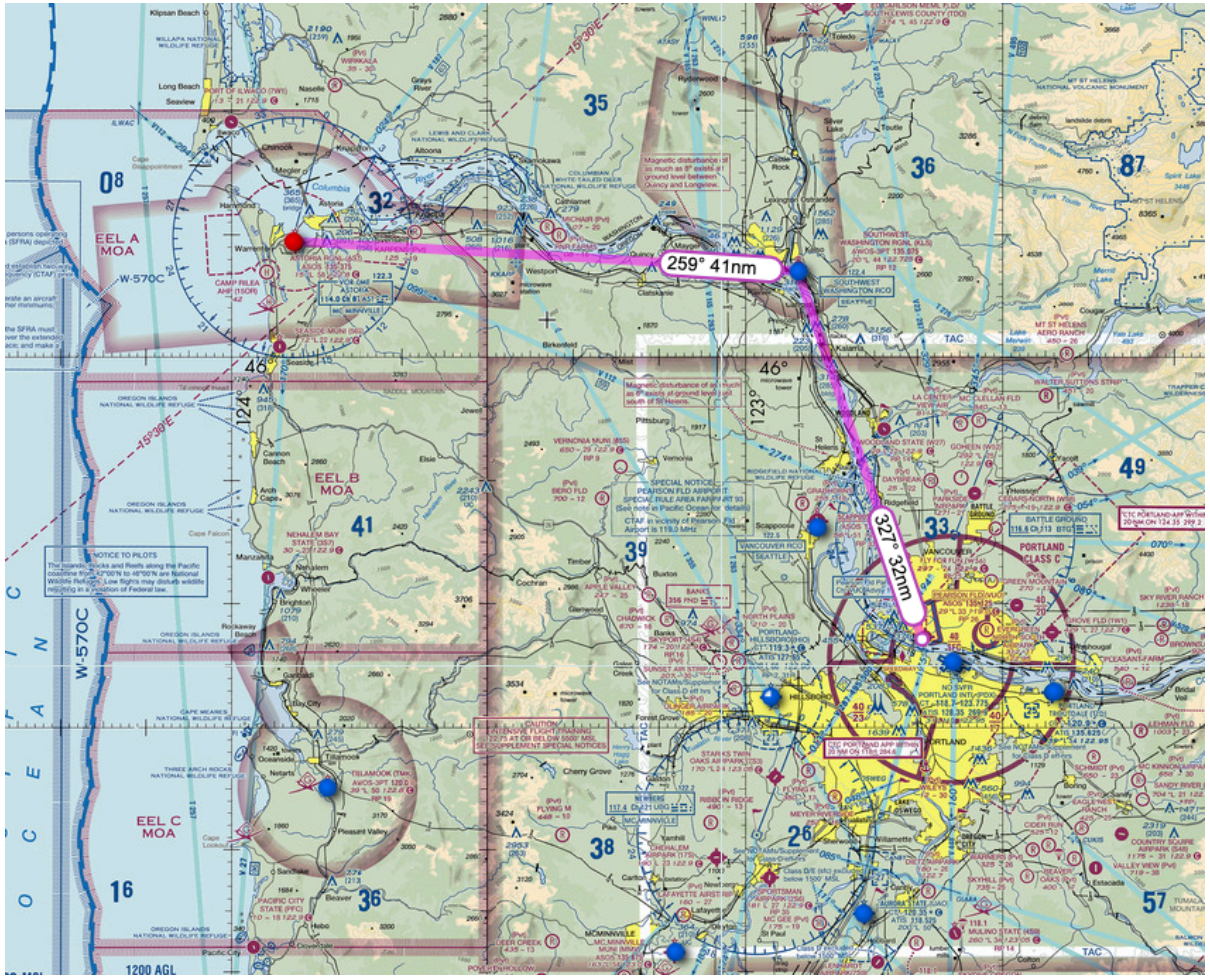
# Knowledge Check

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 mush 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 STANDARD TEMP -9°C | | | STANDARD TEMPERATURE 11°C | | | 20°C ABOVE STANDARD TEMP 31°C | | |
|---|---|---|---|---|---|---|---|---|---|---|
| RPM | MP | % BHP | KTAS | GPH | % BHP | KTAS | GPH | % 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

**SHORT FIELD**

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

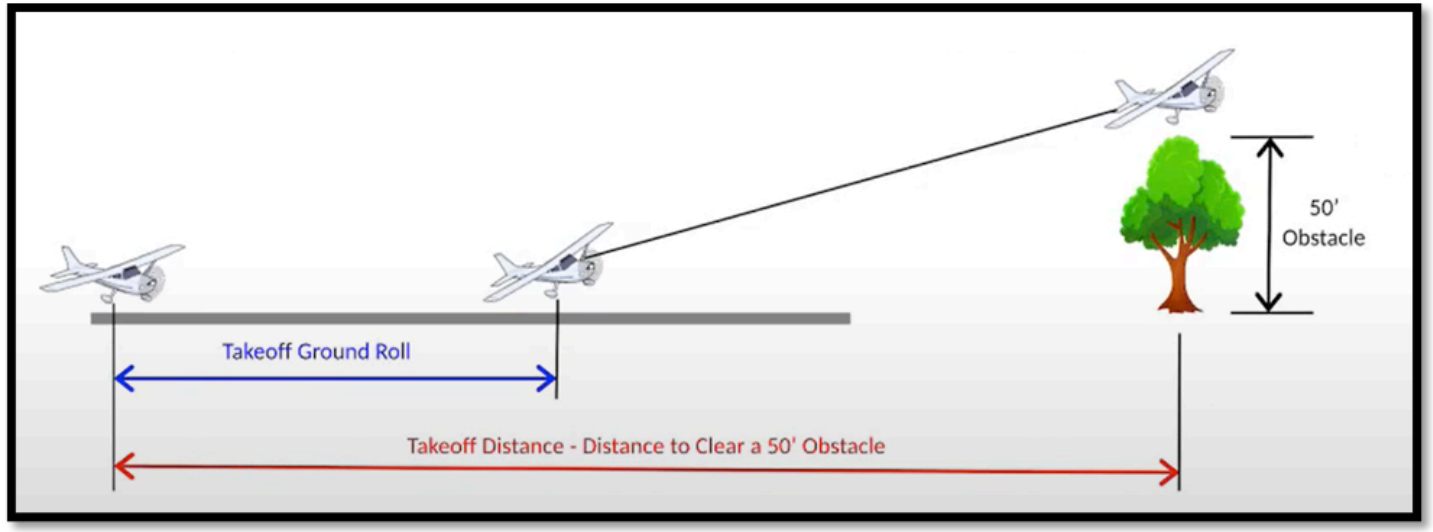
NOTES:
1. Short field technique as specified in Section 4.
2. Decrease distances 10% for each 9 knots headwind. For operation with tailwinds up to 10 knots, increase distances by 10% for each 2 knots.
3. For operation on a dry, grass runway, increase distances by 15% of the "ground roll" figure.

| WEIGHT LBS | TAKEOFF SPEED KIAS | | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LIFT OFF | AT 50 FT | | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 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

**SHORT FIELD**

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

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 LBS | TAKEOFF SPEED KIAS | | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LIFT OFF | AT 50 FT | | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 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 ft.**

4 knot tailwind:

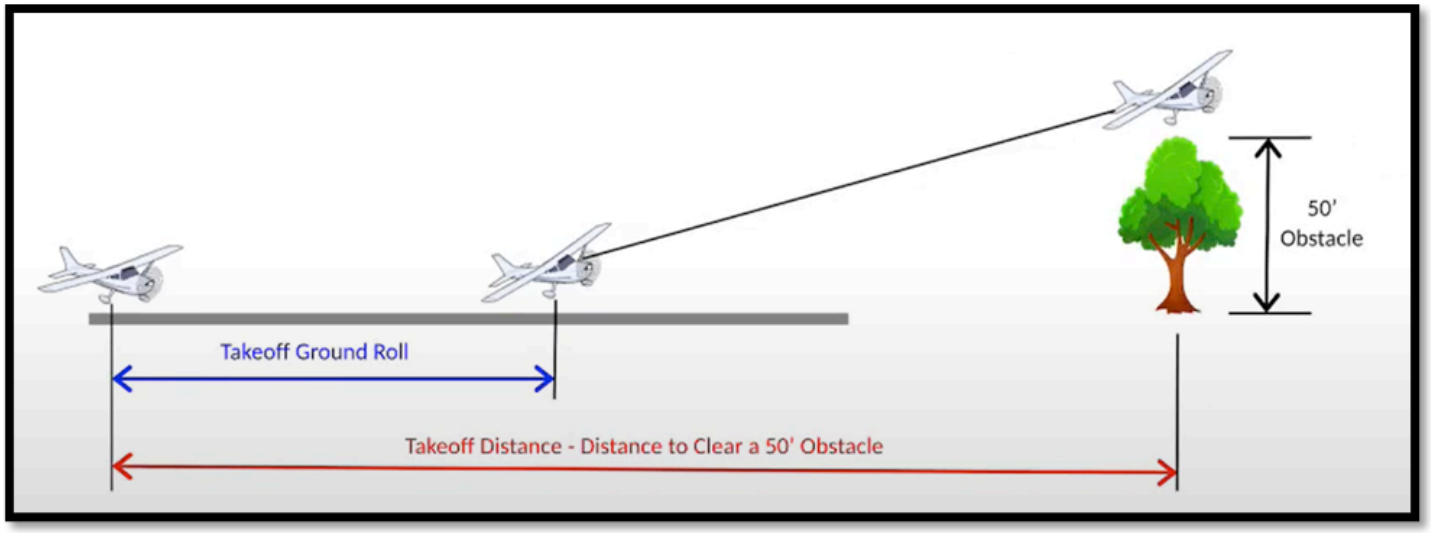
20% increase

820 * 1.2 = **984 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.**

---

With 50% safety factor:

820 * 1.5 = **1230 ft.**

1535 * 1.5 = **2302 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 LBS | PRESSURE ALTITUDE FT | TEMP °C | RATE OF CLIMB FPM | FROM SEA LEVEL | | |
|---|---|---|---|---|---|---|
| | | | | TIME MIN | FUEL USED GALLONS | DISTANCE 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 LBS | PRESSURE ALTITUDE FT | TEMP °C | RATE OF CLIMB FPM | FROM SEA LEVEL | | |
|---|---|---|---|---|---|---|
| | | | | TIME MIN | FUEL USED GALLONS | DISTANCE 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

---

14°C above standard

20% increase

---

8 * 1.2 = **9.6 minutes**

2.9 * 1.2 = 3.5 gallons

14 * 1.2 = **16.8nm**

---

+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 STANDARD TEMP -9°C | | | STANDARD TEMPERATURE 11°C | | | 20°C ABOVE STANDARD TEMP 31°C | | |
|---|---|---|---|---|---|---|---|---|---|---|
| RPM | MP | % BHP | KTAS | GPH | % BHP | KTAS | GPH | % 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**

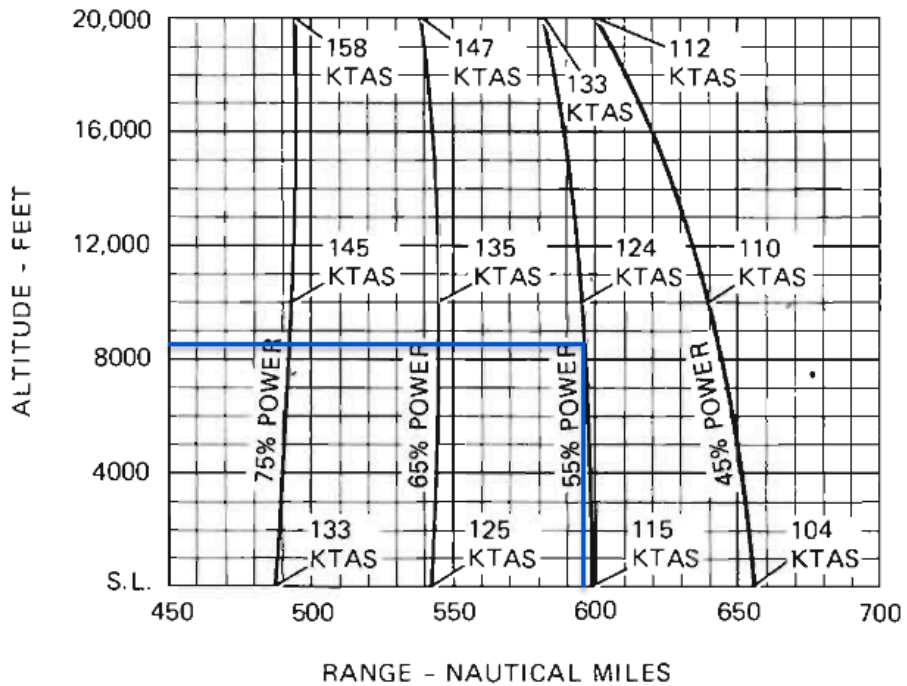
For best fuel economy, operate at the leanest mixture that results in smooth engine operation or at peak EGT.

| | | 20°C BELOW STANDARD TEMP -25°C | | | STANDARD TEMPERATURE -5°C | | | 20°C ABOVE STANDARD TEMP 15°C | | |
|---|---|---|---|---|---|---|---|---|---|---|
| RPM | MP | % BHP | KTAS | GPH | % BHP | KTAS | GPH | % 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

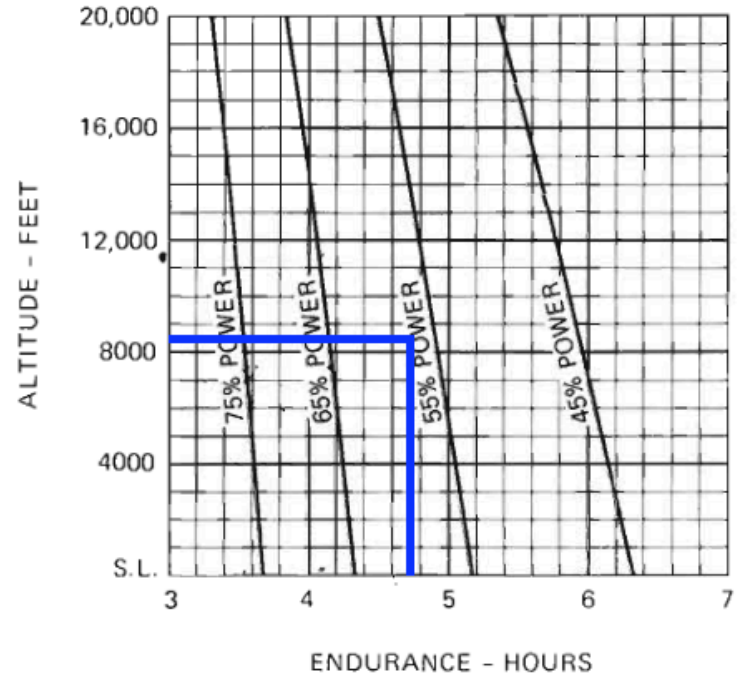
NOTE:
This chart allows for the fuel used for engine start, taxi, takeoff and climb, and the distance during a normal climb up to 12,000 feet and maximum climb above 12,000 feet.




# 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 LBS | SPEED AT 50 FT KIAS | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 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

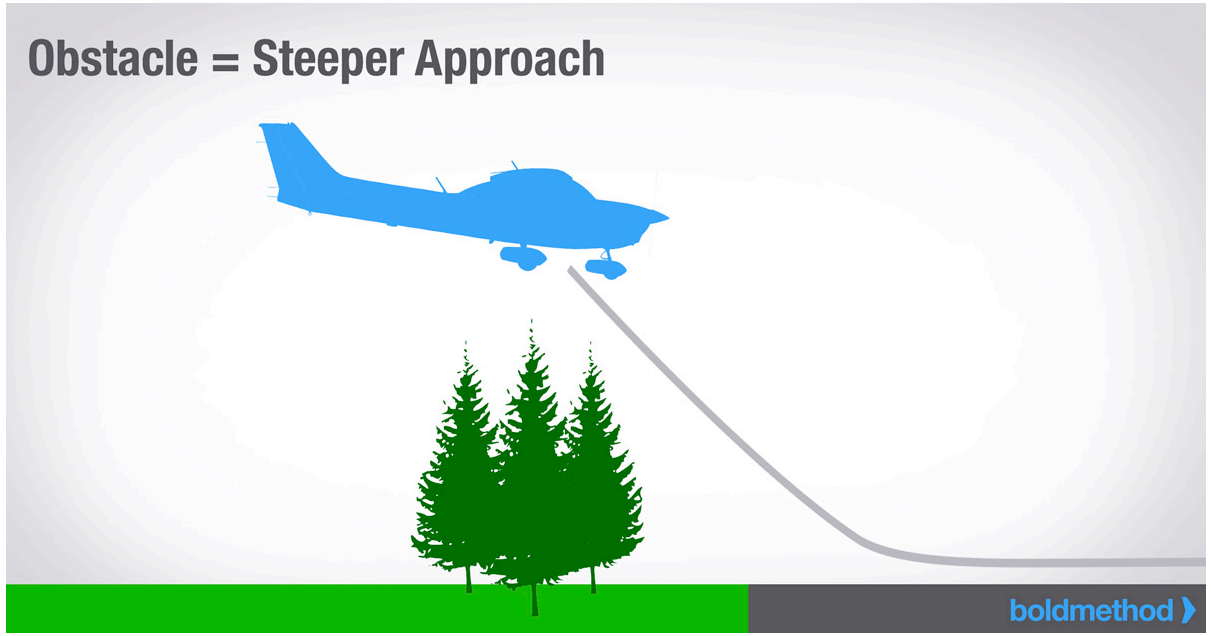
---

Decrease distances 10%

0.9 * 600 = **540 ft. ground roll**

0.9 * 1365 = **1231 ft. over 50' obs.**

# Landing Distance (Short Field) - Safety Factor




540 ft. ground roll

1231 ft. over 50' obs.

---

Ground roll:

540 * 1.5 = **810 ft**

Over 50' obstacle:

1231 * 1.5 = **1846 ft**

# FLAPS 25° TAKEOFF GROUND ROLL

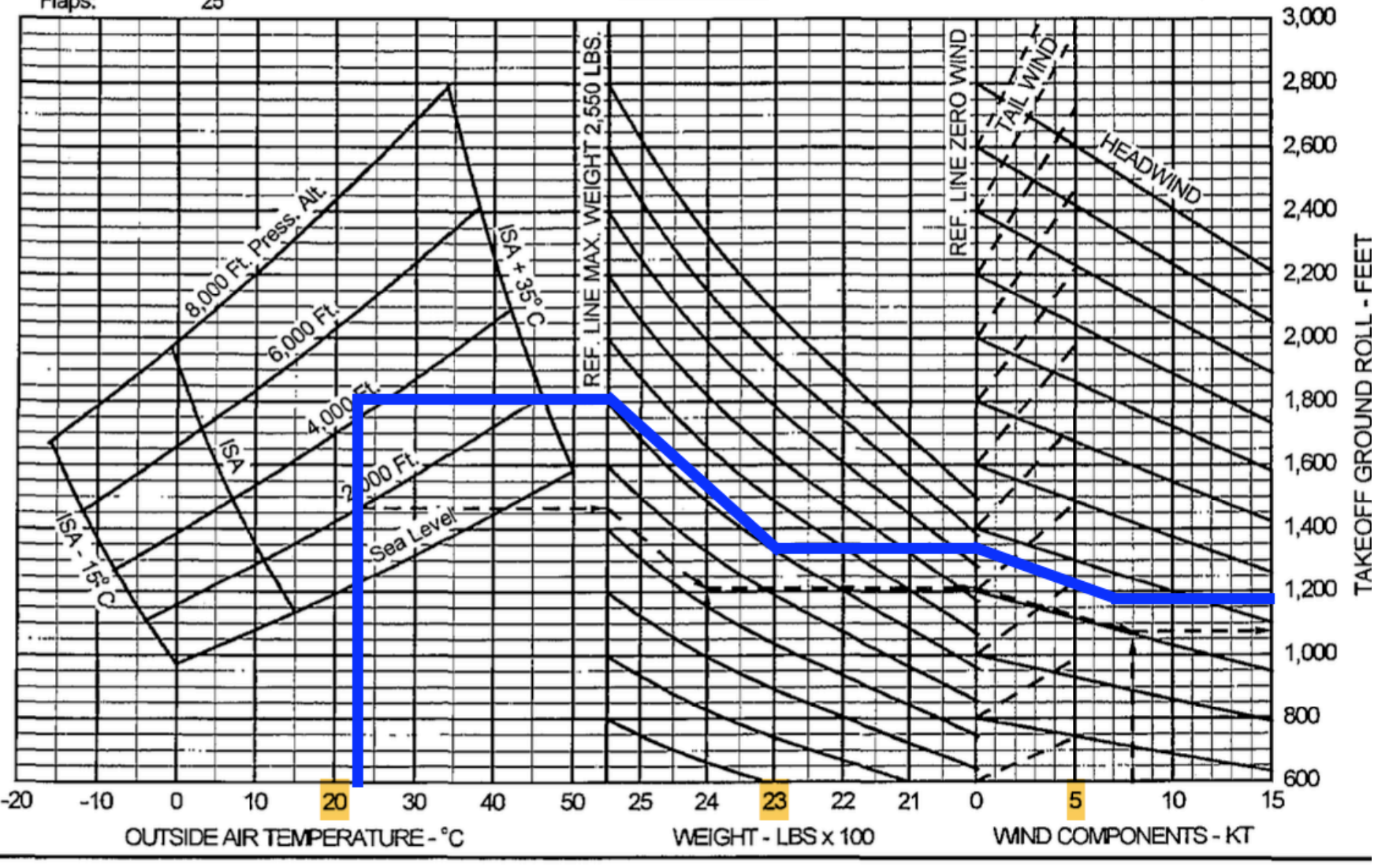
**ASSOCIATED CONDITIONS**

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

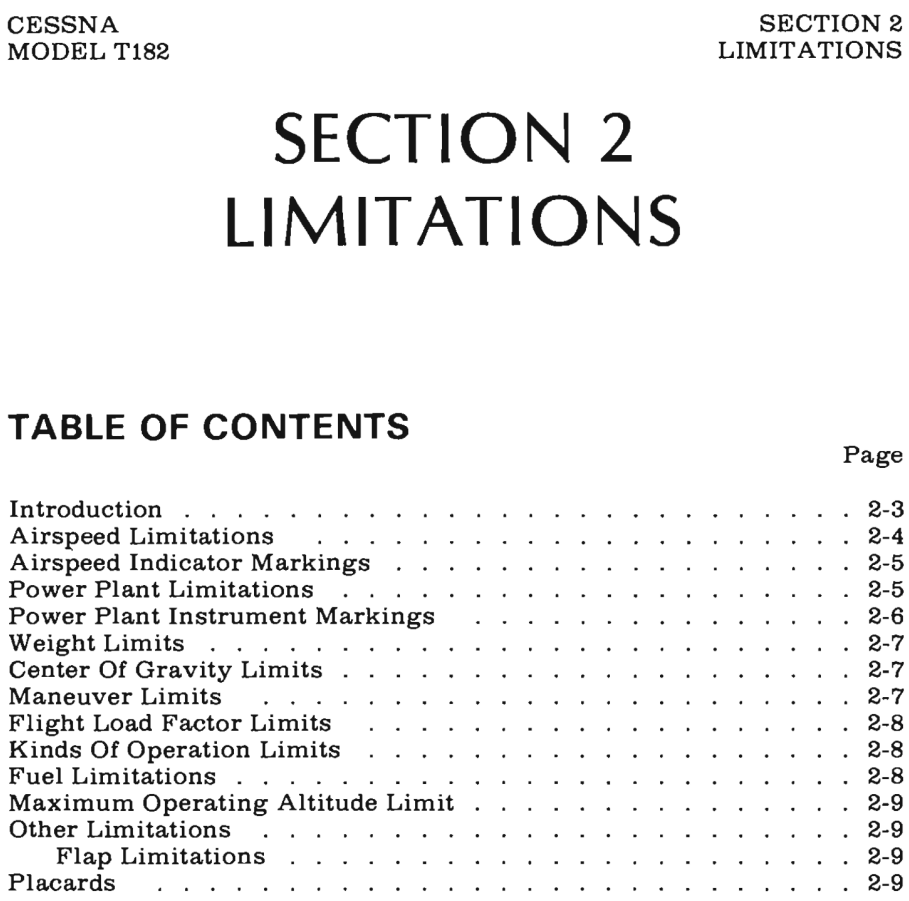
**~1150 ft.**

# 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

### TABLE OF CONTENTS



- POH limitations section
- Placards and markings
- Performance charts

# 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.
uel 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 |
|---|---|---|---|---|
| $V_{NE}$ | Never Exceed Speed | 175 | 178 | Do not exceed this speed in any operation. |
| $V_{NO}$ | Maximum Structural Cruising Speed | 138 | 140 | Do not exceed this speed except in smooth air, and then only with caution. |
| $V_A$ | Maneuvering Speed:<br>3100 Pounds<br>2600 Pounds<br>2100 Pounds | <br>110<br>100<br>90 | <br>111<br>101<br>90 | Do not make full or abrupt control movements above this speed. |
| $V_{FE}$ | Maximum Flap Extended Speed:<br>To 10° Flaps<br>10° - FULL Flaps | <br>138<br>95 | <br>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

**SHORT FIELD**

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

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 LBS | TAKEOFF SPEED KIAS | | PRESS ALT FT | 0°C | | 10°C | | 20°C | | 30°C | | 40°C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LIFT OFF | AT 50 FT | | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 50 FT OBS | GRND ROLL | TOTAL TO CLEAR 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