# A104 AIRPLANE PERFORMANCE

References: FAA-H-8083-25A, Pilot's Handbook of Aeronautical Knowledge, Chapter 9 and Chapter 10 (pgs 1-26)

## INTRODUCTION

The objectives of this unit are to learn how to perform the aircraft weight and balance calculation; to describe the effects of the atmosphere on performance; and to calculate the takeoff and landing information. The standards are to perform these objectives.

Knowledge of the Trainer Aircraft's performance under different atmospheric conditions is essential to safe flight. This unit discusses the factors that affect airplane performance, which include the airplane weight, atmospheric conditions, runway environment, and the fundamental physical laws governing the forces acting on an airplane.

To be able to make practical use of the airplane's capabilities, it is essential to understand the significance of the operational data. The pilot must be cognizant of the basis for the airplane performance data, as well as the meanings of the various terms used in expressing airplane performance capabilities and limitations. This lesson will be using the DA-20 C1 Tiger as an example trainer aircraft.

## WEIGHT

Any item aboard the airplane that increases the total weight is undesirable as far as performance is concerned. Manufacturers attempt to make the airplane as light as possible without sacrificing strength or safety. This reduces fuel burn, horsepower requirements, etc. The pilot of an airplane should always be aware of the consequences of overloading. An overloaded airplane may not be able to leave the ground, or if it does become airborne, it may exhibit unexpected and unusually poor flight characteristics. If an airplane is not properly loaded, the initial indication of poor performance usually takes place during takeoff.

Excessive weight reduces the flight performance of an airplane in almost every respect. The most important significant performance reductions are:

- Higher takeoff speed
- Longer takeoff run
- Reduced rate and angle of climb
- Lower maximum altitude
- Shorter range
- Reduced cruising speed
- Reduced maneuverability
- Higher stalling speed
- Higher approach and landing speed
- Longer landing roll
- Excessive weight on the nose wheel

The pilot must be knowledgeable about the effects of weight on the performance of the airplane. Preflight planning must include a check of performance charts to determine if the airplane's weight may contribute to hazardous flight operations.

Excessive weight in itself reduces the safety margins available to the pilot, and becomes even more hazardous when other performance-reducing factors are combined with excessive weight. The pilot must also consider the consequences of an overweight airplane if an emergency condition arises. If an engine fails on takeoff or airframe ice forms, it is usually too late to reduce the airplane's weight to keep it in the air.

Several key terms need to be defined for the discussion about aircraft weight.

**Empty weight**—the airframe, engines, and all items of operating equipment that have fixed locations and are permanently installed in the aircraft. It includes optional and special equipment, fixed ballast, hydraulic fluid, unusable fuel, and undrainable oil.

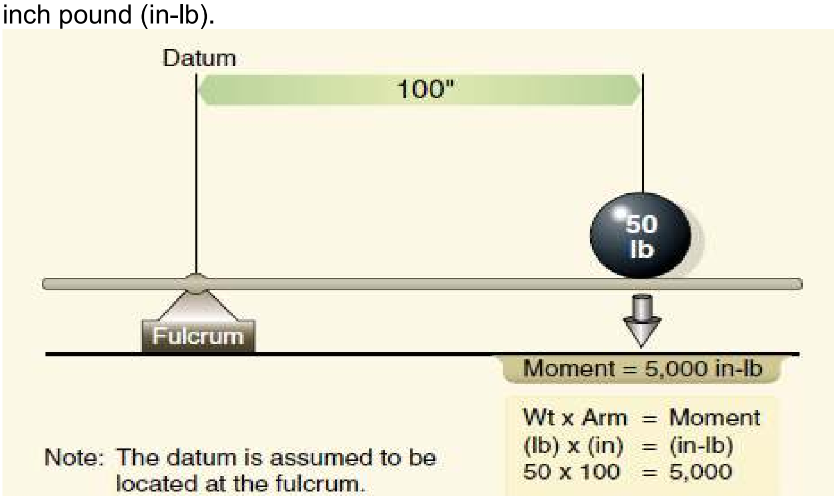
**Useful load—**the weight of the pilot, passengers, baggage, usable fuel, and drainable oil.


**Datum line—**an imaginary vertical plane from which all arm measurements are taken. The datum is established by the manufacturer. All moment arms and the CG range must be computed with reference to this line.

**Arm (moment arm)—**the horizontal distance in inches from the reference datum to the item. The algebraic sign is plus (+) if measured aft of the datum, and minus (-) if measured forward of the datum.

**Station—**a location in the aircraft which is identified by a number designating its distance in inches from the datum. The datum is therefore identified as zero and the station and arm are usually identical.

**Moment—**the product of the weight of an item multiplied by its arm. Moments are expressed in inch pound (in-lb).




**EFFECTS OF BALANCE**

Balance refers to the location of the center of gravity (CG) of an airplane. It is important to airplane stability and safety of flight. The CG is a point at which an airplane would balance if it were suspended at that point. The prime concern of airplane balancing is the fore and aft location of the CG along the longitudinal axis.

The CG is not necessarily a fixed point; its location depends on the distribution of weight in the airplane. As variable load items are shifted or expended, there is a resultant shift in CG location. Because the CG location affects both angle of attack and stability, it has a significant effect on stall speed and ease of recovery.

**AFT CG**
With an aft CG, less downward force on the tail is required to maintain level cruising flight. Hence, an aft CG results in the following:

Stall Speed - As the CG is moved aft, the airplane flies at a lower angle of attack at a given airspeed. Thus, the critical angle of attack will be exceeded at a lower indicated airspeed.

Stability - However, the airplane is less stable because the elevator has a shorter arm (i.e., distance) from the CG and requires greater deflection to produce the same result. Recovery from a stall and spin may become impossible with the CG aft of the range.

Airspeed - With an aft CG, less downward force on the tail is required, resulting in less lift required by the wing. The wing flies at a lower angle of attack with less drag resulting in a higher cruise speed.

**FORWARD CG**
With a forward CG, a greater downward force on the tail is required to maintain level cruising flight. Hence, a forward CG results in the following:

Stall Speed – The total lift required from the wing is increased. Thus, the wing flies at a higher angle of attack, which results in more drag and a higher indicated stall speed.

Stability - However, the airplane is more stable because the elevator has a longer arm (i.e., distance) from the CG and requires less deflection.

Airspeed - More downward force on the tail is required, resulting in more lift required by the wing. The wing flies at a higher angle of attack with more drag resulting in a slower cruise speed.

## TERMS AND DEFINITIONS

The pilot must be familiar with the terms used in working the problems related to weight and balance. The following list of terms and their definitions is well standardized, and knowledge of these terms will help the pilot better understand weight and balance calculations of any airplane.

**Arm (moment arm)** — is the horizontal distance in inches from the reference datum line to the center of gravity of an item. The algebraic sign is plus (+) if measured aft of the datum, and minus (–) if measured forward of the datum.

**Center of gravity (CG)** — is the point about which an airplane would balance if it were possible to suspend it at that point. It is the mass center of the airplane, or the theoretical point at which the entire weight of the airplane is assumed to be concentrated. It may be expressed in inches from the reference datum, or in percent of mean aerodynamic chord (MAC).

**Center of gravity limits** — are the specified forward and aft points within which the CG must be located during flight. These limits are indicated on pertinent airplane specifications.

**Center of gravity range** — is the distance between the forward and aft CG limits indicated on pertinent airplane specifications.

**Datum (reference datum)** — is an imaginary vertical plane or line from which all measurements of arm are taken. The datum is established by the manufacturer. Once the datum has been selected, all moment arms and the location of CG range are measured from this point.

**Maximum landing weight** — is the greatest weight that an airplane is allowed to have at landing.

**Maximum ramp weight** — is the total weight of a loaded aircraft, and includes all fuel. It is greater than the takeoff weight due to the fuel that will be burned during the taxi and runup operations. Ramp weight may also be referred to as taxi weight.

**Maximum takeoff weight** — is the maximum allowable weight for takeoff.

**Maximum weight** — is the maximum authorized weight of the aircraft and all of its equipment as specified in the Type Certificate Data Sheets (TCDS) for the aircraft.

**Moment** — is the product of the weight of an item multiplied by its arm. Moments are expressed in pound-inches (lb-in). Total moment is the weight of the airplane multiplied by the distance between the datum and the CG.

**Moment index (or index)** — is a moment divided by a constant such as 100, 1,000, or 10,000. The purpose of using a moment index is to simplify weight and balance computations of airplanes where heavy items and long arms result in large, unmanageable numbers.

**Standard empty weight** — consists of the airframe, engines, and all items of operating equipment that have fixed locations and are permanently installed in the airplane; including fixed ballast, hydraulic fluid, unusable fuel and full engine oil.

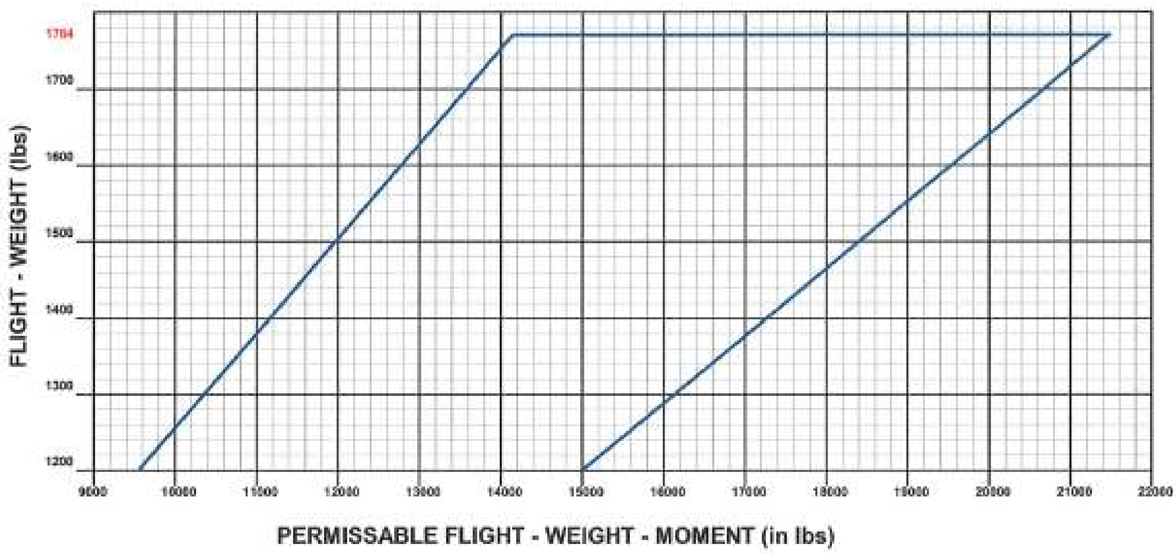
## DETERMINING LOADED WEIGHT AND CENTER OF GRAVITY

There are various methods for determining the loaded weight and center of gravity of an aircraft. There is the computation method, as well as methods that utilize graphs and tables provided by the aircraft manufacturer. The DA20-C1 utilizes the table method.

| N 932DA | WEIGHT: | 1208.00 | ARM: | 8.32 | MOMENT: | 10050.56 |
|---|---|---|---|---|---|---|

| Fuel load > | 1/2 (12 gal) | | | 3/4 (18 gal) | | | Full (24 gal) | | |
|---|---|---|---|---|---|---|---|---|---|
| Crew Weight (lbs) | WEIGHT | ARM | MOMENT | WEIGHT | ARM | MOMENT | WEIGHT | ARM | MOMENT |
| 100 | 1392.10 | 9.58 | 13341.76 | 1428.10 | 10.16 | 14509.60 | 1464.10 | 10.71 | 15677.44 |
| 110 | 1402.10 | 9.56 | 13398.06 | 1438.10 | 10.13 | 14565.90 | 1474.10 | 10.67 | 15733.74 |
| 120 | 1412.10 | 9.53 | 13454.36 | 1448.10 | 10.10 | 14622.20 | 1484.10 | 10.64 | 15790.04 |
| 130 | 1422.10 | 9.50 | 13510.66 | 1458.10 | 10.07 | 14678.50 | 1494.10 | 10.61 | 15846.34 |
| 140 | 1432.10 | 9.47 | 13566.96 | 1468.10 | 10.04 | 14734.80 | 1504.10 | 10.57 | 15902.64 |
| 150 | 1442.10 | 9.45 | 13623.26 | 1478.10 | 10.01 | 14791.10 | 1514.10 | 10.54 | 15958.94 |
| 160 | 1452.10 | 9.42 | 13679.56 | 1488.10 | 9.98 | 14847.40 | 1524.10 | 10.51 | 16015.24 |
| 170 | 1462.10 | 9.39 | 13735.86 | 1498.10 | 9.95 | 14903.70 | 1534.10 | 10.48 | 16071.54 |
| 180 | 1472.10 | 9.37 | 13792.16 | 1508.10 | 9.92 | 14960.00 | 1544.10 | 10.44 | 16127.84 |
| 190 | 1482.10 | 9.34 | 13848.46 | 1518.10 | 9.89 | 15016.30 | 1554.10 | 10.41 | 16184.14 |
| 200 | 1492.10 | 9.32 | 13904.76 | 1528.10 | 9.86 | 15072.60 | 1564.10 | 10.38 | 16240.44 |
| 210 | 1502.10 | 9.29 | 13961.06 | 1538.10 | 9.84 | 15128.90 | 1574.10 | 10.35 | 16296.74 |
| 220 | 1512.10 | 9.27 | 14017.36 | 1548.10 | 9.81 | 15185.20 | 1584.10 | 10.32 | 16353.04 |
| 230 | 1522.10 | 9.25 | 14073.66 | 1558.10 | 9.78 | 15241.50 | 1594.10 | 10.29 | 16409.34 |
| 240 | 1532.10 | 9.22 | 14129.96 | 1568.10 | 9.76 | 15297.80 | 1604.10 | 10.26 | 16465.64 |
| 250 | 1542.10 | 9.20 | 14186.26 | 1578.10 | 9.73 | 15354.10 | 1614.10 | 10.24 | 16521.94 |
| 260 | 1552.10 | 9.18 | 14242.56 | 1588.10 | 9.70 | 15410.40 | 1624.10 | 10.21 | 16578.24 |
| 270 | 1562.10 | 9.15 | 14298.86 | 1598.10 | 9.68 | 15466.70 | 1634.10 | 10.18 | 16634.54 |
| 280 | 1572.10 | 9.13 | 14355.16 | 1608.10 | 9.65 | 15523.00 | 1644.10 | 10.15 | 16690.84 |
| 290 | 1582.10 | 9.11 | 14411.46 | 1618.10 | 9.63 | 15579.30 | 1654.10 | 10.12 | 16747.14 |
| 300 | 1592.10 | 9.09 | 14467.76 | 1628.10 | 9.60 | 15635.60 | 1664.10 | 10.10 | 16803.44 |
| 310 | 1602.10 | 9.07 | 14524.06 | 1638.10 | 9.58 | 15691.90 | 1674.10 | 10.07 | 16859.74 |
| 320 | 1612.10 | 9.04 | 14580.36 | 1648.10 | 9.56 | 15748.20 | 1684.10 | 10.04 | 16916.04 |
| 330 | 1622.10 | 9.02 | 14636.66 | 1658.10 | 9.53 | 15804.50 | 1694.10 | 10.02 | 16972.34 |
| 340 | 1632.10 | 9.00 | 14692.96 | 1668.10 | 9.51 | 15860.80 | 1704.10 | 9.99 | 17028.64 |
| 350 | 1642.10 | 8.98 | 14749.26 | 1678.10 | 9.49 | 15917.10 | 1714.10 | 9.97 | 17084.94 |
| 360 | 1652.10 | 8.96 | 14805.56 | 1688.10 | 9.46 | 15973.40 | 1724.10 | 9.94 | 17141.24 |
| 370 | 1662.10 | 8.94 | 14861.86 | 1698.10 | 9.44 | 16029.70 | 1734.10 | 9.92 | 17197.54 |
| 380 | 1672.10 | 8.92 | 14918.16 | 1708.10 | 9.42 | 16086.00 | 1744.10 | 9.89 | 17253.84 |
| 390 | 1682.10 | 8.90 | 14974.46 | 1718.10 | 9.40 | 16142.30 | 1754.10 | 9.87 | 17310.14 |
| 400 | 1692.10 | 8.88 | 15030.76 | 1728.10 | 9.37 | 16198.60 | 1764.10 | 9.84 | 17366.44 |
| 410 | 1702.10 | 8.86 | 15087.06 | 1738.10 | 9.35 | 16254.90 | | | |
| 420 | 1712.10 | 8.84 | 15143.36 | 1748.10 | 9.33 | 16311.20 | | | |
| 430 | 1722.10 | 8.83 | 15199.66 | 1758.10 | 9.31 | 16367.50 | | | |
| 440 | 1732.10 | 8.81 | 15255.96 | | | | | | |
| 450 | 1742.10 | 8.79 | 15312.26 | | | | | | |
| 460 | 1752.10 | 8.77 | 15368.56 | | | | | | |
| 470 | 1762.10 | 8.75 | 15424.86 | | | | | | |

Once the total weight of the aircraft is determined and the total moment is calculated, the location of the CG must be found.




**PERFORMANCE**
Performance is a term used to describe the ability of an airplane to accomplish certain things that make it useful for certain purposes. For example, the ability of the airplane to land and takeoff in a very short distance is an important factor to the pilot who operates in and out of short, unimproved airfields. Airplane performance depends upon the number of air molecules available.

First, the engine derives its power from oxygen molecules in the air reacting with fuel molecules to produce energy. More molecules mean more energy.

Second, the wing produces lift in proportion to the number of air molecules flowing over it. More molecules mean more lift.

Third, the propeller produces thrust by accelerating many air molecules and hurling them rearward so that Newton's third law is used. More molecules mean more thrust.

**STANDARD ATMOSPHERE DEFINITION**
The International Standards Association (ISA) has defined a Standard Atmosphere as:
Sea Level Barometric Pressure of 29.92 inches of Mercury (in. Hg)
Sea Level Temperature of 15° Celsius (15°C or 59°F)
Relative humidity of 0%
Standard temperature lapse rate of 2°C per 1000 feet altitude
Standard pressure lapse rate of 1 inch Hg per 1000 feet altitude

There are three main characteristics of air that directly affect aircraft performance:

- altitude
- temperature
- humidity

These three factors combined constitute what we normally refer to as density altitude, the effective or "performance altitude" at which the aircraft is operating.

**ALTITUDE**
The atmosphere is a vapor composed of free molecules of nitrogen, oxygen, and a number of other trace compounds all moving about at high rates of speed and colliding with one another and any other object that may get in the way. Each of these molecules has mass. Mass attracts mass in proportion to the amount of mass: the law of gravity.

The molecules of air closest to the earth's surface are pulled toward the center of the earth with greater force than those farther away, resulting in more molecules per unit volume (greater density) close to the earth's surface.

At sea level, we can expect an air density in the neighborhood of 1,000 hectopascals. At 18,000 feet, expect half that density, around 500 hectopascals. At 100,000 feet, somewhat above the service ceiling of most training aircraft, the air density will be only about 10 hectopascals. So, what do we need to take away from all that? All else being equal, higher altitude equals lower air density.

**PRESSURE/TEMPERATURE**

The number of molecules in a given volume of air varies with pressure. Higher pressure means more molecules. The number of molecules varies with temperature. Higher temperature means fewer molecules because they are farther apart. Using these two facts (pressure and temperature), you can calculate the density of air under various combinations of temperature and pressure.

**PRESSURE ALTITUDE**

Pressure altitude is the height above a standard datum plane. As previously discussed, the airplane altimeter is essentially a sensitive barometer calibrated to indicate altitude in the standard atmosphere. If the altimeter is set for 29.92 in. Hg Standard Datum Plane (SDP), the altitude indicated is the pressure altitude — the altitude in the standard atmosphere corresponding to the sensed pressure.

The SDP is a theoretical level where the weight of the atmosphere is 29.92 in. Hg as measured by a barometer. As atmospheric pressure changes, the SDP may be below, at, or above sea level. Pressure altitude is important as a basis for determining aircraft performance as well as for assigning flight levels to airplanes operating at or above 18,000 feet. The pressure altitude can be determined by either of two methods:

1. By setting the barometric scale of the altimeter to 29.92 and reading the indicated altitude, or

2. By applying a correction factor to the indicated altitude according to the reported "altimeter setting."

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28.05 | +1776 | 28.80 | +1053 | 29.55 | +345 | 30.30 | -348 |
| 28.10 | +1727 | 28.85 | +1005 | 29.60 | +298 | 30.35 | -394 |
| 28.15 | +1678 | 28.90 | +957 | 29.65 | +252 | 30.40 | -440 |
| 28.20 | +1630 | 28.95 | +910 | 29.70 | +205 | 30.45 | -485 |
| 28.25 | +1581 | 29.00 | +863 | 29.75 | +159 | 30.50 | -531 |
| 28.30 | +1533 | 29.05 | +815 | 29.80 | +112 | 30.55 | -576 |
| 28.35 | +1484 | 29.10 | +768 | 29.85 | +66 | 30.60 | -622 |
| 28.40 | +1436 | 29.15 | +721 | 29.90 | +20 | 30.65 | -667 |
| 28.45 | +1388 | 29.20 | +673 | 29.95 | -26 | 30.70 | -712 |
| 28.50 | +1340 | 29.25 | +626 | 30.00 | -73 | 30.75 | -758 |
| 28.55 | +1292 | 29.30 | +579 | 30.05 | -119 | 30.80 | -803 |
| 28.60 | +1244 | 29.35 | +532 | 30.10 | -165 | 30.85 | -848 |
| 28.65 | +1196 | 29.40 | +485 | 30.15 | -211 | 30.90 | -893 |
| 28.70 | +1148 | 29.45 | +439 | 30.20 | -257 | 30.95 | -938 |
| 28.75 | +1100 | 29.50 | +392 | 30.25 | -303 | 31.00 | -983 |

Pressure altitude can be approximated using the table above. The number in the left column is the current altimeter setting for the airfield in question. The corresponding number in the right column (red) should be added to (or subtracted from) field elevation to estimate pressure altitude for that airfield.

**TEMPERATURE**
Temperature also has a significant effect on air density. Remember all those little molecules bouncing about? Temperature is simply a measurement of heat energy, and heat energy produces increased molecular motion or velocity.

The molecules that make up the fluid we call air, move faster and collide more often and with more force as heat energy increases. Increasing the force and frequency of molecular collision results in the molecules increasing the distance between them, which reduces density. We simply have fewer molecules per unit volume in warm air than in cool air. So, higher air temperature equals lower air density.

**HUMIDITY**
Humidity, the amount of water vapor in air, is the third factor we set out to explore. It is the least significant of the three, but it is an interesting factor and worth understanding. Intuitively, we think of water as being much heavier than air. In its liquid form, that is certainly true, but we are talking about water in vapor form, where the molecules are free to move about and exhibit the properties of a gas.

**DENSITY ALTITUDE**
This altitude is pressure altitude corrected for variations from standard temperature. When conditions are standard, pressure altitude and density altitude are the same. If the temperature is above standard, the density altitude is higher than pressure altitude. If the temperature is below standard, the density altitude is lower than pressure altitude. This is an important altitude because it is directly related to the airplane's performance.

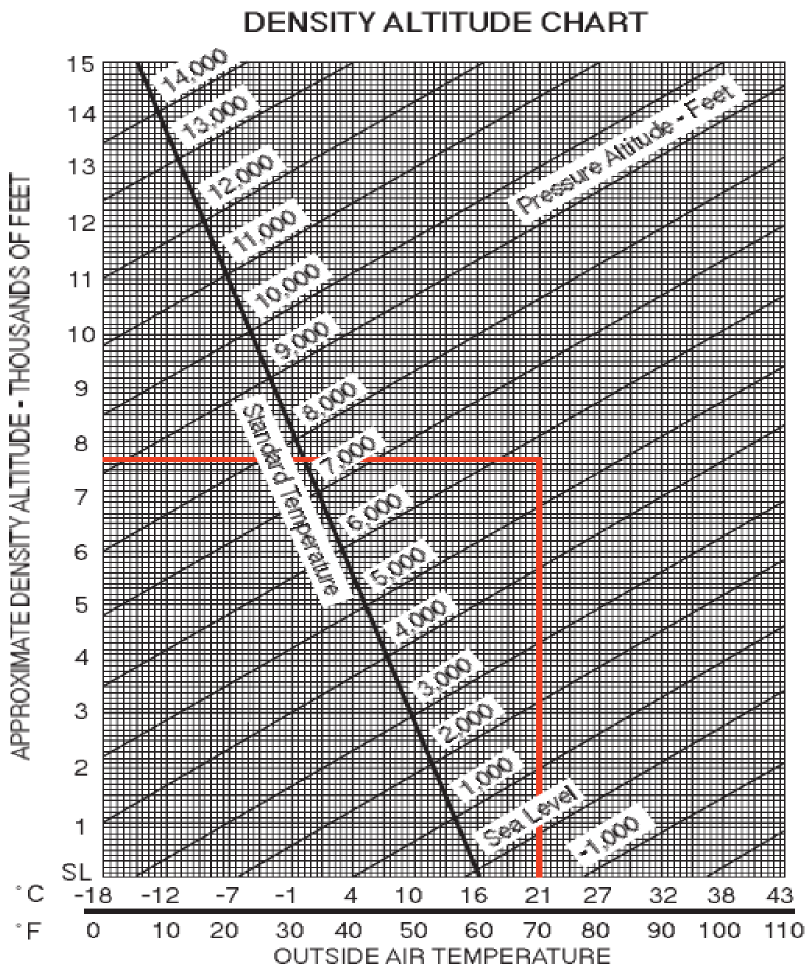
Air density decreases with:
Air temperature increase,
Altitude increase,
Humidity increase,
Barometric pressure decrease.

With lower air density:
The engine develops less power.
The propeller produces less thrust.
The wings produce less lift.

This results in:
Longer takeoff run,
Poorer climb performance,
Longer landing distance.

Density Altitude is used in calculating aircraft performance. Under standard atmospheric condition, air at each level in the atmosphere has a specific density, and under standard conditions, pressure altitude and density altitude identify the same level. Density Altitude, then, is the vertical distance above sea level in the standard atmosphere at which a given density is to be found.

The conditions that result in a high density altitude are high elevations, low atmospheric pressures, high temperatures, high humidity, or some combination of these factors. Lower elevations, high atmospheric pressure, low temperatures, and low humidity are indicative of low density altitude.




| 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 |
| 31.0 | -983 |

Determine the density altitude based on the given information.

Airport elevation........5,883 feet
OAT..................................70°F
Altimeter................30.10 in. Hg

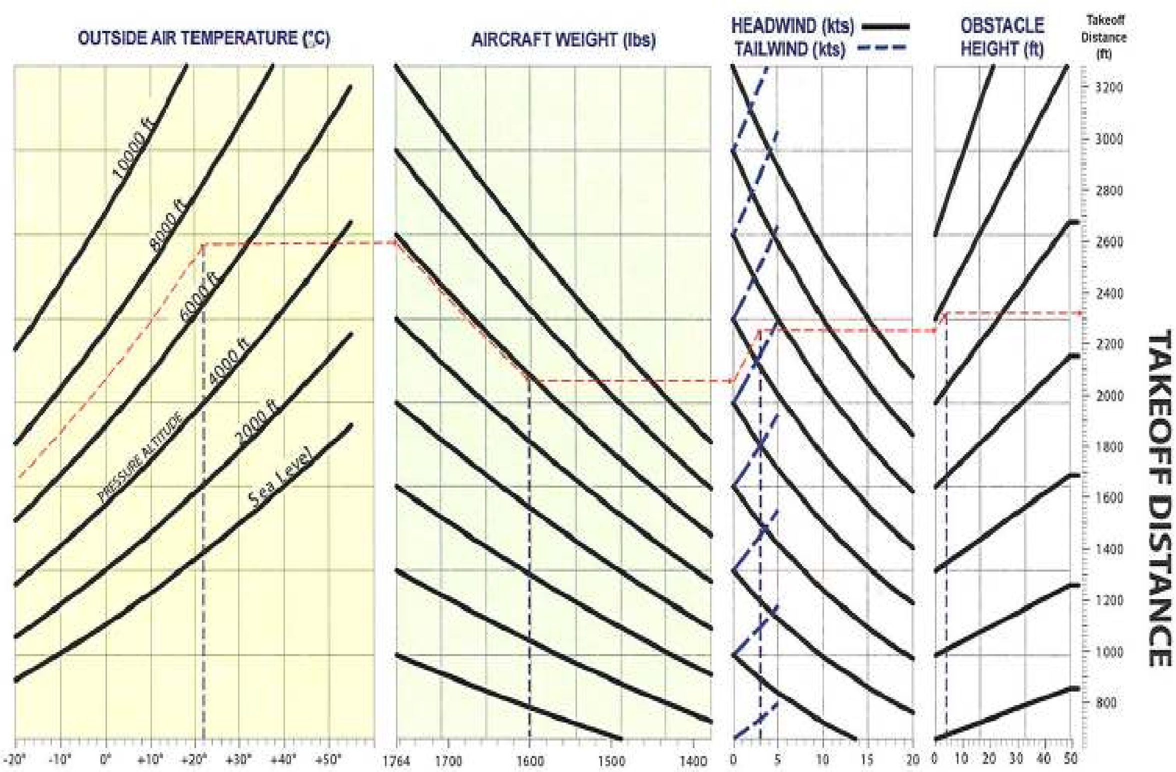
- Find 30.10 under the altimeter setting.
- Read across to the second column. It reads “-165.” Subtract 165 from the airport elevation. This results in a pressure altitude of 5,718 feet.
- Locate the outside air temperature on the scale along the bottom of the graph.
- From 70°, draw a line up to the 5,718 feet diagonal pressure altitude line, which is about two-thirds of the way up between the 5,000 and 6,000-foot lines.
- Draw a line straight across to the far left side of the graph and read the approximate density altitude.
- The approximate density altitude is 7,700 feet.

**AIRCRAFT PERFORMANCE**
For the purpose of this training, performance is described in terms of takeoff distance, landing distance, and crosswind performance. The data in the performance charts for the Diamond DA20-C1 is calculated in relation to pressure altitude and temperature.

**TAKEOFF PERFORMANCE**
Takeoff performance data shown in the manufacturers' charts indicates the minimum runway requirements necessary for successful takeoff. Any factor that adversely affects the takeoff distance must be taken into account to insure safe operation. Consider that the listed minimum distance is for standard atmospheric conditions, ideal runway and wind conditions.

CONDITIONS:
> Maximum takeoff power
> Lift-off speed 52 KIAS
> Level runway, paved
> Wing flaps in T/O position

EXAMPLE:
> Pressure altitude: 7000ft
> Outside Air Temperature: 72° F (22° C)
> Weight: 1600 lbs
> Wind: 3kt tailwind
> Obstacle: 15ft
> Result: Take-off distance to clear a 5 ft obstacle is 2375 ft




Wind direction and velocity significantly affect takeoff performance. A direct headwind, for example, will decrease takeoff distance … a crosswind will have a negligible effect on takeoff distance … while a tailwind will increase takeoff distance. To the maximum extent possible, plan all takeoffs (and landings) into the wind.

Gross weight affects takeoff performance. Increased gross weight requires a higher takeoff speed in order to achieve sufficient lift. This results in reduced acceleration due to greater inertia and increased rolling friction, further reducing acceleration.

NOTE: Maybe this will help you to understand the relationship between air density (# of available air molecules) and indicated airspeed. If you are looking at 160 knots on an airspeed indicator, consider that it takes a certain amount of air molecules to be shoved into the pitot tube to make that speed appear! There are fewer molecules at a much higher altitude than at a lower altitude. Hence, if you 'indicate' 160 at 3,000 feet, in order to indicate 160 at 30,000 feet, your aircraft is actually moving much, much faster to collect the sparse air molecules! Indicating 160 at 30,000 feet, you may have a true airspeed of 220 knots over the ground, if no wind is affecting you. Calibrated and Equivalent airspeeds are for testing and advanced flight-related activities beyond our scope at UPT.

**TAKEOFF BRIEFING**
At the end of the Runup checklist, the Takeoff Briefing is given. The pilot states the planned performance of the aircraft based on the current atmospheric conditions. "Runway 26L, 3,767 feet available, 2,800 feet required, winds 230° at 10 knots, left crosswind."

**LANDING PERFORMANCE**
The minimum landing distance is attained by landing at the minimum safe speed which allows sufficient margin above the stall speed for satisfactory control and go-around capability. Gross weight and headwind are important considerations in determining minimum landing distance. Excessive airspeed above that recommended in the POH will significantly increase landing distance. High density altitude increases landing distance. As a rule of thumb, the increase in landing distance is about 3.5% for each 1,000 feet in density altitude.

- Landing distance -To clear a 50 foot obstacle

- Landing roll distance - is the distance from touchdown until the airplane comes to a stop by using the recommended braking technique.

EXAMPLE:
Standard Setting, 4000 ft
Landing distance over a 50 ft obstacle: approx. 1457'
Landing roll distance: approx. 700'

## LANDING DISTANCE

| Height above MSL (ft) | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 |
|---|---|---|---|---|---|---|---|---|
| **Landing Distance (ft)** | 1344 | 1370 | 1399 | 1428 | 1457 | 1489 | 1522 | 1555 |
| **Landing Roll Distance (ft)** | 610 | 640 | 659 | 680 | 700 | 721 | 744 | 766 |

**NOTE:** This table assumes the following conditions:
1. Throttle IDLE
2. Maximum takeoff weight
3. Approach speed 55 KIAS
4. Runway is level and paved
5. Flaps in the LDG position
6. Standard setting, MSL

**NOTE:** Due to ground idle speed set at 1000 RPM, figures in this table have already been adjusted in accordance with the note in AFM 5.3.11 Revision 23. Landing distances reflect a 5% increase. Ground roll distances reflect a 7% increase.

**NOTE:** Landing distance may increase considerably if deviating from normal operating procedure, or in unfavorable weather conditions (e.g., high outside air temperature, rain, unfavorable wind conditions, slippery runway, etc.).

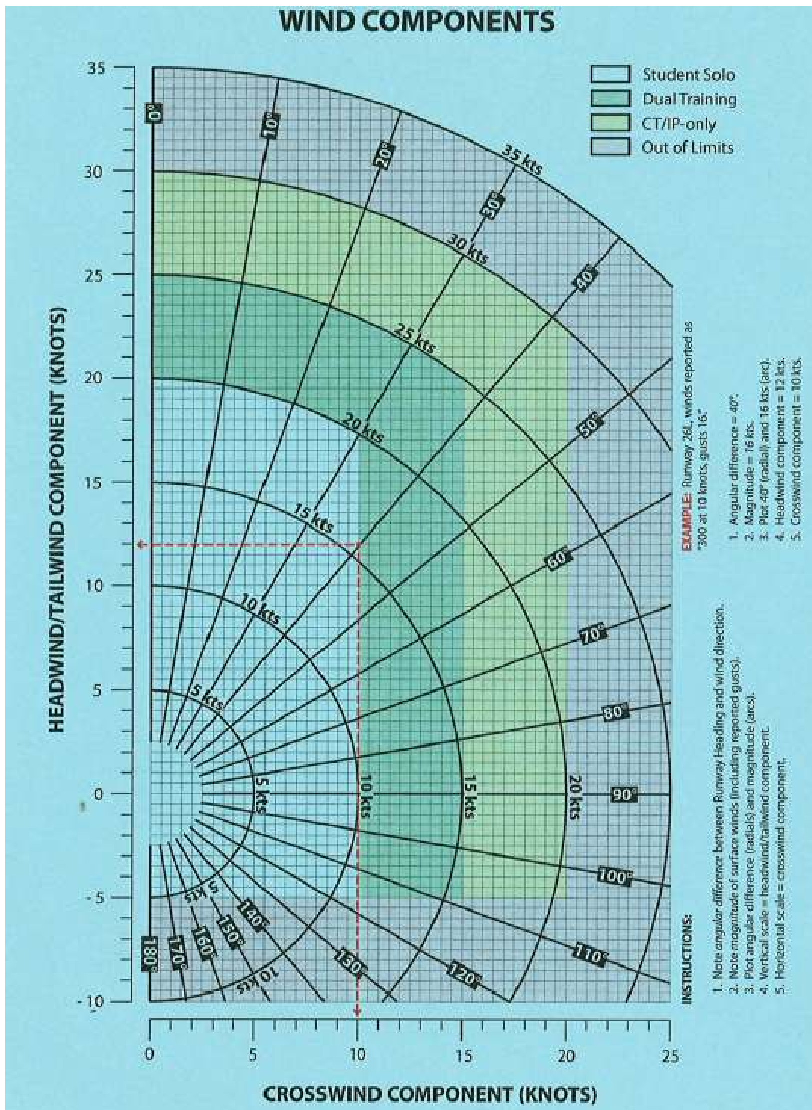
**APPROACH BRIEFING**

The approach briefing is an item in the Descent/Approach checklist. “Runway 26L via initial, left pattern, 5,500 feet.” Even though the landing performance is not stated, the pilot must still determine that the runway has sufficient length for landing.

**CROSSWIND PERFORMANCE**

Takeoffs and landings under significant crosswind conditions can be dangerous and should be avoided. Crosswinds can be so strong that the sideways drift cannot be sufficiently overcome by using a “sideslip” into the wind to compensate for the wind drift. Excessive side load on the landing gear can cause gear failure or an upset aircraft. The Maximum Crosswind Component for the aircraft will be listed in the Flight Information Manual (FIM). The chart below can be used to calculate the headwind and crosswind components. In the chart, the numbers around the periphery of the chart mark the degrees difference between the wind and the runway heading. The radial lines are in 5° increments with numbers on each 10° line.

First, determine how many degrees difference there is between the runway and the wind direction. It is known that runway 17 means a direction of 170° and from that, subtract the wind direction of 140°. This gives a 30° angular difference. This is the wind angle.




Next, locate the 30° mark and draw a line from there until it intersects the correct wind velocity of 40 knots. From there, draw a line straight down and a line straight across. The headwind component is 35 knots and the crosswind component is 20 knots. This information is important when taking off and landing so that, first of all, the appropriate runway can be picked if more than one exists at a particular airport, but also so that the airplane is not pushed beyond its tested limits. Takeoffs and landings should be accomplished into the wind to the maximum extent possible.

**BRAKING**

A number of factors affect braking. A wet, icy or snow covered runway will appreciably decrease braking ability. In crosswinds or gusty conditions, a higher than normal approach speed may be flown to improve controllability, but will result in an extended landing roll. A down-sloping runway also increases stopping distance. Braking immediately after touchdown is ineffective because the wings are still producing lift. The pilot should use the natural aerodynamic drag as much as possible to slow the aircraft. Maintain up-elevator to a high angle of attack as long as possible. The nose of the aircraft will settle naturally as airspeed is dissipated. Therefore, it is not necessary (and is unwise) to force the nose wheel down onto the runway.

**PERFORMANCE SPEEDS**

**Indicated Airspeed (IAS)** the speed of the airplane as observed on the airspeed indicator. It is the airspeed without correction for indicator, position (or installation), or compressibility errors.

**Calibrated Airspeed (CAS)** the airspeed indicator reading corrected for position (or installation), and instrument errors. (CAS is equal to TAS at sea level in standard atmosphere.) The color-coding for various design speeds marked on airspeed indicators may be IAS or CAS.

**True Airspeed (TAS)** the speed of the airplane in relation to the air mass in which it is flying. It is IAS corrected for air density.

**Equivalent Airspeed (EAS)** the airspeed indicator reading corrected for position (or installation), or instrument error, and for adiabatic compressible flow for the particular altitude. (EAS is equal to CAS at sea level in standard atmosphere.)

**Ground Speed (GS)** the speed of the airplane in relation to the ground over which it is flying. It is TAS corrected for winds.

**V** speeds (aircraft) are speeds that define certain performance and limiting characteristics of an aircraft and the "V" stands for velocity. They are established by the manufacturer during design and testing, and are specific to the aircraft characteristics of the individual aircraft.

**$V_{S0}$**- the calibrated power-off stalling speed or the minimum steady flight speed at which the airplane is controllable in the landing configuration.


**$V_{S1}$**- the calibrated power-off stalling speed or the minimum steady flight speed at which the airplane is controllable in a specified configuration.

**$V_Y$**- the calibrated airspeed at which the airplane will obtain the maximum increase in altitude per unit of time. This best rate-of-climb speed normally decreases slightly with altitude.

**$V_X$**- the calibrated airspeed at which the airplane will obtain the highest altitude in a given horizontal distance. This best angle-of-climb speed normally increases slightly with altitude.

**$V_{FE}$**- the highest calibrated airspeed permissible with the wing flaps in a prescribed extended position. This is because of the air loads imposed on the structure of the flaps.

**$V_A$**- the calibrated design maneuvering airspeed. This is the maximum speed at which the limit load can be imposed (either by gusts or full deflection of the control surfaces) without causing structural damage.

**$V_{NO}$**- the maximum calibrated airspeed for normal operation or the maximum structural cruising speed. This is the speed at which exceeding the limit load factor may cause permanent deformation of the airplane structure.

**$V_{NE}$**- the calibrated airspeed which should NEVER be exceeded. If flight is attempted above this speed, structural damage or structural failure may result.

Best angle of climb ($V_X$) is performed at an airspeed that will produce the most altitude gain in a given distance. $V_X$ is considerably lower than best rate of climb, $V_Y$, and is the airspeed where the most thrust is available over that required for level flight. $V_Y$ will result in a steeper climb path, although the airplane will take longer to reach the same altitude than it would at $V_Y$. $V_X$ is used in clearing obstacles after takeoff.

Best rate of climb ($V_Y$) is performed at an airspeed where the most excess power is available over that required for level flight. This condition of climb will produce the most gain in altitude in the least amount of time (maximum rate of climb in feet per minute). $V_Y$ made at full allowable power is a maximum climb. It must be fully understood that attempts to obtain more climb performance than the airplane is capable of by increasing pitch attitude will result in a decrease in the rate of altitude gain.

It should be noted that, as altitude increases, the speed for $V_X$ increases, and the speed for $V_Y$ decreases. The point at which these two speeds meet is the absolute ceiling of the airplane.

**MISSION DATA CARD**
The Mission Data Card is filled out for every sortie. It is used to record all of our essential information needed for the safe completion of the sortie.

-The names of the left and right seat occupants are listed along with their weights.
-The Lesson number is recorded.
-The Operational Risk Management (ORM) is calculated and recorded for both the Student Pilot and the Instructor Pilot.
-The aircraft tail number is written down after receiving the assignment from the SOF.
-The Call Sign is filled in from the Daily Flight Schedule.
-The Profile and Area are also recorded from the Daily Flight Schedule.
-The Step Time, Engine Start Time, Takeoff Time and Land Time all come from the Flight Schedule.
-The Area and Pattern Entry/Exit Times are determined by the SP and IP.
-The ATIS/AWOS/WX is filled in when taxiing to the runway or at arrival to the airport.
-The SOF instructions are exactly that.
-The Baffles are for the airplane engine performance and are given by the SOF.
-The takeoff and landing times are the actual times for the sortie.
-In order to be prepared for an emergency, the altitudes for a forced landing procedure are determined from the Practice Area map. The planned landing site is determined and the elevation from the contour lines is recorded in the Elevation blank. Add 500’ to that figure and record the number in the 500’ blank. Add 800’ to the Elevation number for the Low Key altitude. Add 1600’ to the Elevation number for the High Key altitude.
-The Training Objectives are the SP’s personal objectives of what he/she desires to accomplish on the sortie.
-The METAR is the current weather that is being reported.

-The TAF is the weather that is forecasted for the sortie time period.
-The NOTAMs are the Notices To Airman that affect the sortie.
-The Status is given by the SOF and recorded.
-The FCIF is the Flight Crew Reading File and the most current FCIF number is written here.
-The TOLD is the Takeoff and Landing Data for each airport on the sortie.
-The aircraft weight is recorded.
-The headwind and tailwind are listed.
-The temperature is recorded.
-The pressure altitude is computed from the Inflight Guide (IFG).
-The landing and takeoff distances are taken from the performance charts in the IFG and added together to get the TOLD.
-The runway and the takeoff and landing distances available are recorded for each airport.
In the Mission Flow area, the types of traffic patterns to be flown are listed and the flight maneuvers to be practiced in the area are listed.