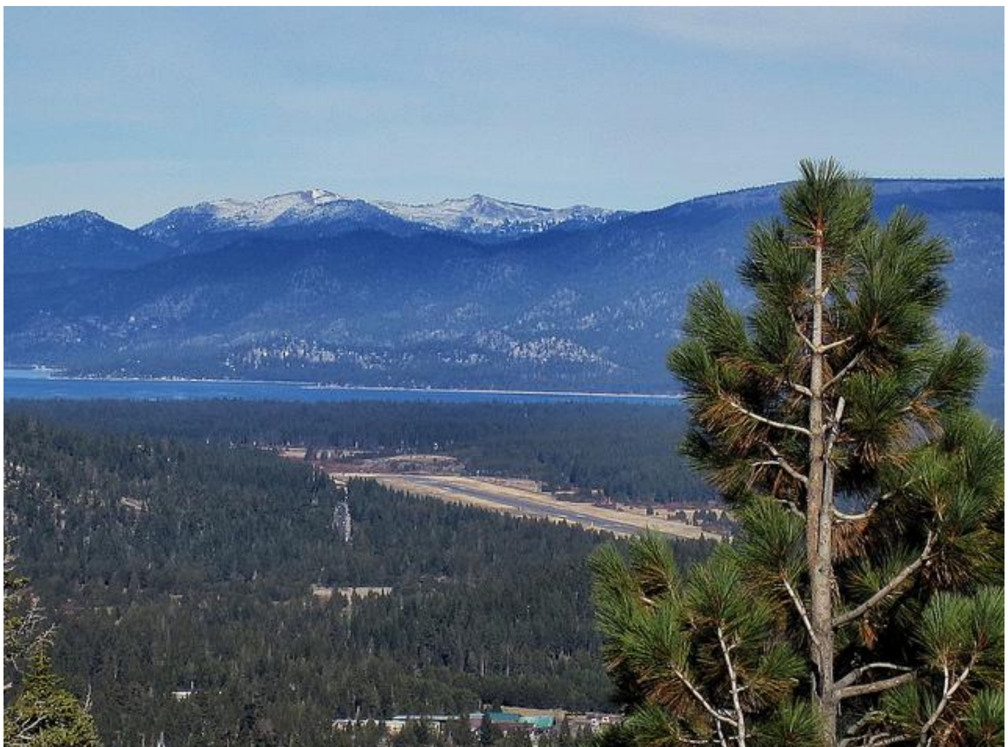
Wings Flight School



Wings Flight School

Mountain Checkout Student Training Syllabus

Pickup Mountain Checkout syllabus from Wings Flight School
Schedule 1 2hr block of ground instruction with instructor

Session 1-Ground *2.0 on the ground*

Come prepared having read required material and completed checkout worksheet
Be prepared to discuss the following:

- High Density altitude
- Wind Shear
- Illusions
- Thunderstorms
- Air Craft Performance
- Mountain Flight procedures
- Emergency procedures
- Tahoe airport and environment

Schedule aircraft and instructor for two 2hr blocks.

Session 2-Flight Truckee/Reno Checkout

2.5-in the air Postflight 0.3

Wings Flight School

Wings Flight School

High-Altitude Checkout Worksheet

Student Name: ____

CFI Name:________________________ Date:________________________

Aircraft Make /Model _______________________________________

High Altitude Checkout as per WFS's Operational Agreement

Article 1, Section 2:

I. To qualify at Pilot in Command (PIC) or as solo student pilot in an WFS airplane, a renter must pass a competency check for the conditions listed below, as considered appropriate to the certificates and ratings held, given by an AFI Flight Training Center Instructor.

Article 1, Section 2 (b)

I. For High-altitude Airport Operation

1. Tahoe/Truckee/Reno Field elevations?____
2.Traffic Pattern Altitude ?____
3.Runway Length? ____
4.What is the CTAF or Unicom Frequency?_____________________________________
5.What are the traffic pattern directions for:

   KTVL Runway 36? ______ Runway 18?

   KTRK Runway 02_______ Runway 20___ Runway 11? Runway 29________

   KRNO Runway 16L/R ____ Runway 34R/L______ Runway 07-25______

6.Are fuel and maintenance available at the airport?_____________________________
7.What is the Flight Service frequency for the area? _____________________________
8.Does the airport have any visual slope indicators?______________________________

   If so, what kind?______________________________

9.Is there automated weather information available at the airport?

   If so, what kind?___________ If so, what telephone number would be used?_____

10.Are there any noise abatement procedures?__________ If so, what are they? ______

____

____

____

11.What Features of Tahoe/Truckee/Reno are unique and possibly hazardous around the airport?

____

____

____

12.Are there any weather related problems associated with high altitude and mountain flying?_________________What would they be?_______________________________

____

____

____

Wings Flight School

Performance Problem:

Given Conditions:

Wind:	290/10
Temp:	85° F
Altimeter:	30.25
Aircraft:	Max Gross Take Off Weight

13. What is the Pressure Altitude? ____

14. What is the Density Altitude? ____

15. What is your takeoff climb speed? ____

16. What is the takeoff distance over a 50 foot obstacle? __________________________

17. What is the landing distance over a 50 foot obstacle? __________________________

18. What is your final approach speed? ____

19. What is the Rate of Climb?____

Wings Flight School

Takeoff and Climbout

If density altitude is 3,000 feet or higher, have pilot perform engine lean-out (normally aspirated engines only, in accordance with the POH) for takeoff, and determine proper flap settings.

Have the student identify takeoff and abort points on the field, and review the departure routing. The instructor pilot should note the actual takeoff point relative to the predicted takeoff point and record the difference for later discussion. To estimate the distance, count the number of seconds that liftoff occurs before or after reaching the predicted liftoff point. You may convert this time to distance during the postflight review by multiplying the rotation speed in knots true airspeed by the number of seconds from the expected takeoff point and multiply by 1.7 to get distance in feet.

Example: 5 seconds past the expected liftoff point with a rotation speed of 70 knots true -- 5 x 70 x 1.7 = 595 feet.

The Student should establish a climb at Vy. Wait for the VSI to stabilize and record the initial rate of climb on the data form. Alternatively, you can time one minute of climb and record the altitude gained. This is a more accurate method than using the VSI.

Climb to at least 3,000 feet AGL or 5,000 feet DA (whichever is higher) for the first set of maneuvers.

Airplane Configurations and Power Setting vs Airspeed

The first set of maneuvers is intended to provide a performance baseline for comparison to these maneuvers when flown at mountain altitudes.

Establish airspeed (approximately 85 KIAS, as appropriate to the aircraft) with flaps up. Record the power setting required for this airspeed.

Perform medium bank turns (30° of bank) left and right.

Extend flaps to setting (10-25° flap, as appropriate to the aircraft). Record power setting required for this airspeed.

Extend landing gear (for retracts) and full flaps, fly at normal speed for approach to landing and maintain level flight. Record power required.

Simulate a go-around by applying full power with gear/flaps down. Fly at the speed listed in the POH for Vy max gross weight with gear and flaps up. Record the rate of climb obtained.

Maintain the climb and slow down in 5 knot increments. Note the airspeed which produces the greatest rate of climb in this configuration, and record this airspeed and the rate of climb achieved.

Raise the gear and flaps. Perform a departure stall with full power. Resume level flight.

Slow flight: Decrease airspeed to just above stall speed — intermittent activation of the stallwarning horn is OK. Perform turns left and right in a shallow bank (10-15°) with coordinated use of the rudder.

Perform an approach to landing stall with power off.

Resume level flight with flaps at setting. Resume airspeed. Descents:

Reduce power to idle, extended full flaps at normal approach speed. Record rate of descent. Increase speed to approach speed for flaps up. Raise flaps. Perform a maximum effort slip. Record the rate of descent.

Resume coordinated flight and transition to a climb with full power.

Takeoffs and Landings

The goal of these maneuvers is to hone skills in maximum performance takeoffs and landings. Increased proficiency will be very useful for the high altitude airport operations.

Perform at least 3 takeoffs and landings, including short and soft field takeoffs and landings, and power off approach / landing. Estimate and record actual landing distance for short and soft field landings.

Postflight Debrief

Review the data recorded during the flight for comparison to POH data. This provides the Student with an objective look at how much of the book performance they can obtain. Compare estimated to actual values for takeoff and landing distances, rates of climb, and time to complete 180 degree turns. Time and airspeed can be used to calculate the turn diameter. Also review the power settings needed to maintain level flight with flaps and landing gear upand down, and the airspeed that produced the best rate of climb with flaps and gear down.

This review should aid in the Student in more fully understanding the performance capability of the airplane.

Satisfactory performance is a judgment call on behalf of the Check Pilot. If the pilot understands the requirements and can execute those requirements in accordance with the FAA test standards for his rating in the judgment of the Check Pilot, the pilot’s records should be endorsed.

Detailed Description of Emergency Course Reversal Maneuvers:

The Canyon Turn (steep turn)

The canyon turn is an **emergency maneuver** used to reverse course with a level turn that requires the least possible distance in turn diameter. It also requires the least forward distance. When properly executed this maneuver approaches the structural certification limit (2.0 g withflaps deployed) and aerodynamic limit (stall speed) of the aircraft to obtain the minimum achievable turn diameter. **It should only be used to escape from emergencysituations** such as turning into a narrow valley in which the aircraft cannot out climb the terrain, or when the aircraft has been inadvertently maneuvered to head directly into terrain atvery close distance.

For any turn, the diameter of the turn increases by the square of the airspeed and decreases with the tangent of the bank angle. The net result is that the tightest turn that an aircraft can make in level flight is at the **steepest bank angle** which can be safely flown at the **smallest margin above stall speed which the pilot can safely maintain**. There are limits tohow much bank angle can be used however. Since induced drag increases with increasing bank angle, very steep bank angles will require more power than may be available, and this will cause the aircraft to descend during such a turn even if full power is used.. The g load produced by a very steep bank can also exceed the structural limitations of the aircraft. And finally, a very steep bank is difficult to maintain accurately and makes it difficult to perform this maneuver precisely.

Operations are usually conducted with partial flap extension to improve stall margin and deck angle at airspeed. Since all normal category light aircraft have at least a 2 g loadlimit with flap extension, all such aircraft can safely use a **60 degree bank** for this maneuver. Also, the **decrease in stall speed from using a partial flap setting** allows the maneuver to be flown at a slower speed than with flaps up. For most aircraft this will allow a turn to be made with flaps in a smaller diameter than at a steeper bank angle with flaps up.

The **ideal entry speed** for the maneuver is one that is **slightly higher than the stall speed in a 60 degree bank**. The stall speed in a 60 degree bank is 1.4 times the stall speed in level flight. To calculate the entry speed, multiply the CALIBRATED stall speed for the amount of flaps you're using from the POH by 1.4 and add 5 to 10 knots (depending on your skill level). Here are some typical speeds for common Wings aircraft:

Cessna 172: **81 to 86 KIAS (?check these numbers?)**
Cessna 177: **75 to 80 KIAS**
BE-76: 92 to 97 KIAS

Stall speed varies by model year, so you should **check your POH** for applicability. Also note that **stall speed decreases as aircraft weight decreases** by approximately **half the percentage decrease in aircraft gross weight**. Thus when flying at lighter weights than maximum gross slower entry airspeeds may be used. If the conditions are turbulent higher speeds are necessary in order to maintain a safe margin above stall speed.

The safest way to begin this maneuver is from level flight, without attempting a pitch up before rolling in. If you have a small amount of excess airspeed over the optimum entry airspeed, you can bleed that speed off as you maintain altitude in the turn. If you have a large amount of excess airspeed you may want to pull up to slow down first, but it's best to return the nose to a level attitude before rolling in to the turn as this minimizes the chances for an inadvertent stall.

Since this maneuver is flown with the wing at a high angle of attack, the induced drag is increased which also increases the power required to maintain level flight. **The power required will often exceed the power available**, even at full throttle. Still, an early and smooth application of full power will aid in performing the maneuver with the least possible loss of altitude.

You should be looking outside of the aircraft, slightly to the side of nose. Note the horizon picture relative to the cowl as you roll in to the turn as this shows you the approximate pitch attitude to maintain through the turn. If you raise the nose unintentionally the aircraft can stall before the maneuver is completed. If you let the nose drop you may lose an excessive amount of altitude before completing the turn.

Roll the aircraft to approximately 60 degrees of bank with aileron and coordinated use of rudder. **Keep the ball centered** -- an uncoordinated stall from this attitude could be fatal at low altitude. Upon reaching this bank angle reduce aileron input to neutral or as necessary to maintain the bank angle. As you roll in apply just enough back pressure to maintain the pitch attitude you saw before you began the roll. To achieve the minimum possible turn radius smoothly increase back pressure on the control yoke until the stall warning begins to sound, then stop increasing back pressure. If the nose starts to drop, roll out slightly until the nose rises to the entry attitude, then roll back in to a 60 degree bank. Begin to roll out when safely headed away from terrain.

If performed correctly, 180 degrees of turn will be accomplished in about 11 seconds in a C-177 at an altitude of 10,000 feet density altitude. For a C-172, it'd be about 10 seconds. The forward travel would be equivalent to that of flying straight ahead for less than 4 seconds. This is indeed a very tight turn.

The Modified Wingover

The modified wing-over is another emergency maneuver used to reverse course in a small amount of space. The name of this maneuver is deceptive -- the only things it shares in common with the wingover known to aerobatic pilots is its name and the general appearance of the maneuver. It is vastly different in execution however, and its goals are different as well.

You should not attempt this maneuver on your own before you have received dual instruction on it unless you have training and proficiency in spin recoveries.

As with the canyon turn, this maneuver **should only be used to escape from emergency situations**. The maneuver is highly dynamic, with constant changes of pitch, bank, heading, and airspeed. If you do not handle the controls as described here, you stand a very good chance of executing a stall/spin which would likely be fatal if entered at typical altitudes.

This maneuver is designed to use the natural stability of the aircraft in pitch and bank to let the aircraft fly itself out of danger while minimizing pilot control inputs that could lead to a departure from controlled flight (i.e. stall/spin).

Enter the maneuver from normal airspeed with an **abrupt pull-up to approximately 30 degrees of pitch attitude**. At this point, **fully release back pressure** on the yokeand **apply moderate rudder pressure** in the desired direction of turn. **Ailerons should remain neutral** throughout the maneuver. Some pilots completely let go of the yoke afterthe pull-up to ensure that they make no inadvertent aileron or elevator inputs. The goal of usingthe controls this way is to not apply hazardous control inputs due to the excitement of escaping from a dangerous situation.

As soon as you release back pressure the natural pitch stability of the airplane will cause the nose to start to come back down. Airspeed will be decreasing however as the nose is still above level flight attitude. The airplane will not stall though, as there is no up elevator to cause the wing to exceed its stall angle of attack. The natural yaw-roll stability of the airplane will cause the rudder pressure to roll the airplane into a bank. The ball on the turn coordinator will stay centered and the aircraft will remain in coordinated flight because there is no adverse yaw from the ailerons (which have remained centered). If you apply back pressure or aileron here you risk stalling the aircraft in uncoordinated flight with potentially disastrous consequences.

Rudder pressure should be eased off as the bank angle exceeds 45 degrees, and then reversed as needed to keep the bank angle from exceeding 60 degrees. By this time the nose of the aircraft will be falling through level and the heading should be passing through 90 degrees of turn. You may need to apply back pressure at this point to keep the nose from dropping too low which will lead to an excessive loss of altitude and a wider turn. Recover from the turn with back pressure and coordinated aileron and rudder to assume a safe heading away from terrain.Note: This technique does not work well with all airplanes used in operations. Some, including the Cessna 172, have an overbanking tendency in the turn which will cause the bank angle to exceed 60 degrees of bank. These aircraft and some others with strong pitch stability will also tend to nose down rapidly after back pressure is released. This will produce excessive altitude loss and increase in speed before the turn is completed. To perform this maneuver in these aircraft you must use aileron opposite to the direction of turn as needed to avoid banking to an excessive bank angle. In addition, some back pressure will be necessary to prevent the nose from dropping to an excessively low pitch attitude. You should practice this maneuver in the aircraft in which you fly to determine whether it works for you in that aircraft. If not, do not use this maneuver.

This maneuver produces a small radius turn with low g-force because turning occurs at a low airspeed while the nose is high. **Stalls are unlikely as the aircraft is being flown "unloaded,"** i.e., with the wing not being required to fly at a high angle of attack to produce increased lift. If you do not release back pressure, the angle to attack of the wing will increase and the airplane could stall. If you limit the bank angle in the turn to 45 degrees, the airplane will not reach 90 degrees of heading change before the nose drops through level flight. The result will be a much wider turn and excessive loss of altitude before the turn is completed.

If performed correctly, the diameter of the turn will be similar to that obtained from using the canyon turn described above. You cannot use this maneuver though when ing just below a cloud deck as you would enter the clouds during the pull-up. This turn also uses up more distance in the forward direction than the canyon turn as there is a delay from the initial pull-up to the initiation of the turn. The gain in altitude will usually not increase terrain clearance as the climb angle of the airplane will usually be less than the angle of a mountain with steep terrain. Still, this maneuver his some merits. You should practice both turn techniques until you are proficient at them, and then decide which you prefer to use under a variety of conditions.

Student's Signature: ____

CFI Signature: ____

Wings Flight School

Mountain Flying
A Primer For High Country Aviating

Depending on where (geographically) you learn to fly, one pilot's every day, normal flying is a foreign environment for another. Take the mountains, for example.
Mention this word, and many may think of John Denver, Colorado, and the Rocky Mountains. But looking at a topographical map of the United States, you'll see that about half of the states have mountains of one elevation or another.

Mountain flying isn't particularly difficult or dangerous, but for those who haven't learned to fly in and around them, it is distinctly different than other types of flying. Without specific knowledge and training, there are some things that will jump up and bite you when you least expect it.

Before introducing mountain flying techniques to "flatlanders" and prospective pilots living in or near the mountains, it's important to understand the mountain flying environment. Besides the mountains, there are three elements that create this flying environment: wind, weather, and density altitude. Although these factors are related, let's examine them individually to see how they contribute to the high- country flying environment.

Wind

Wind is perhaps the single most important element in mountain flying. Flowing through the mountains like water over a rocky stream bed, the interaction of wind and terrain creates updrafts, downdrafts, turbulence, and the "mountain wave," which combines all three elements. Local weather systems develop before your eyes as moist air is forced upward by rising terrain (orographic lifting). Windy conditions often make it difficult or impossible to takeoff or land at a particular airport at a particular time. And local vertical pressure gradients from wind flowing over passes can greatly affect the accuracy of your altimeter.

The analogy of water flowing in a rocky stream can help pilots visualize what happens with mountain winds. As the water approaches a rock, it tends to flow up and over as well as around it. On the rock's downstream side will be a down-flow and turbulence. Wind does the same thing as it flows over high terrain. On the upwind side, we have updrafts; on the downwind side, we have downdrafts and turbulence. Most pilots have at least heard of the mountain wave. It's a condition of disturbed, oscillating airflow caused by orographic lifting of a stable air mass. Mountain waves will have areas of updrafts, downdrafts, and severe or extreme turbulence.

Formation of mountain waves is somewhat predictable. Generally speaking, if the wind is within 30 degrees of perpendicular to the mountain range, the mountaintop winds are more than 15-25 knots (kts) and increase with altitude, and there's a stable air mass (see "Mach 2 Learning," November 1992) or an inversion below about 15,000 feet mean sea level (MSL), then there's the likelihood that mountain waves will form.

Orographic lifting forces the air up the mountain's windward side. The air cools as it rises, and a cap cloud often forms on or above the mountain peaks as the air temperature reaches the dew point. If the air is unstable, it continues to rise, forming cumulus clouds with great vertical development. The mountain wave does not develop in this case, but if the atmosphere is stable, the air begins to flow down the mountain's leeward, or downwind, side. The temperature increases as the air descends, visible moisture dissipates, and the air starts to rise again.

The oscillation is due to a stable atmosphere (air), and the wavelength (distance from crest to crest) is proportional to wind speed and inversely proportional to stability. Typical wavelengths are from 2 to 25 miles, and the wave can extend as far as 150 to 300 miles downwind.

Altocumulus standing lenticular (ACSL) clouds often warn us of mountain waves. We find updrafts on the upwind side of these lens-shaped clouds and downdrafts on the downwind side. Rotor clouds are another signpost of mountain wave activity and are visible beneath the ACSL. They indicate areas of severe, often destructive turbulence below mountaintop level and underneath the ACSL. You won't always see ACSL or rotor clouds when mountain wave is present unless the air is sufficiently moist.
Although mountain waves are not always a contraindication for flying, they should be considered a warning of possible strong winds, turbulence, and up- and downdrafts.

Another wind-related phenomenon you'll see in our rocky-stream analogy occurs as water flows between rocks or through narrow passages. As the flow reaches the constriction, it accelerates and often becomes turbulent. Mountain winds do the same, and wind speed through the passes and down canyons can easily double.
Along with this acceleration is a decrease in pressure. (Does the name "Bernoulli" ring a bell?) This pressure decrease can result in an altimeter error of more than 1,000 feet.

Wind not only affects us when airborne, it can affect our ability to take off or land. Airports near steeply rising terrain can be plagued by turbulence as the air tumbles over a ridge or accelerates through a nearby canyon. Gusty crosswinds can often exceed personal or published aircraft limits, requiring us to stay on the ground or to divert to another airport.

Weather

The mountains are a veritable weather factory. Combine their terrain with wind and moisture, and you'll get rapidly developing localized weather conditions. Sunshine beating down their rugged surface causes uneven heating, which creates thermals, up-slope winds, and other unpredictable air flows. Moist, unstable air and rising terrain is the formula for thunderstorms. Under some conditions, localized pressure gradients can cause airflow over mountain passes to be opposite the prevailing winds aloft, which can surprise even experienced mountain pilots.

Because there are few reporting stations, getting accurate mountain weather information can be difficult, especially in the early morning. And given the mountains' propensity for rapid development of localized weather, what climatic conditions exist between reporting stations can often be a mystery - or a surprise. Often the best mountain weather comes from pilot reports (Pireps), but, again, because conditions change rapidly, a report only an hour old can be very out of date.

In the flatlands, pilots can generally go around or continue on instrument flight rules (IFR, if so rated) if the weather turns sour. But in the mountains, aircraft may not be

able to maintain the IFR minimum enroute altitudes (MEAs), which are often 14,000 MSL or higher and ensure reception of navigation signals and obstacle clearance.
And, even during the summer, you can find ice in the clouds at altitudes below mountaintop level. Such conditions and terrain can eliminate planned and alternate routes.

Density Altitude

Pilots learn that density altitude is pressure altitude corrected for non-standard temperature variations. It could also be called "performance" altitude because it's the altitude at which the aircraft thinks it's flying. In other words, if the density altitude is 10,000 feet, the aircraft will perform as if it were at 10,000 feet, even if the altimeter reads only 6,000.

Density altitude, which pilots learn to compute on their E6B or electronic flight computers, affects aircraft performance basically in two ways: it increases true airspeed and it decreases the amount of power produced by a non-turbocharged engine. Combined, these effects can equal some dramatic changes in aircraft performance.

Wings require a certain mass flow of air over them to generate lift. If the air is thin, the wings must move through the air faster to generate the same amount of lift. The airspeed indicator "reads" the mass of air flowing past the aircraft, so we fly using indicated airspeed. But for every 1,000 feet of density altitude, our true airspeed increases by roughly 2 percent over what our airspeed indicator tells us.

At altitude, we might consider this higher true airspeed an advantage - getting something for nothing - but we pay for it on takeoff and landing. At takeoff, we must accelerate to a higher ground speed before the airspeed indicator reads rotation speed, and that means more runway. On landing, although we're flying the recommended indicated approach airspeed, our true airspeed (and ground speed) is higher. Because landing distance increases with the square of the ground speed, landing distances at high density altitude airports are much longer than at sea level.

Because an engine's fuel/air ratio must remain fairly constant, thinner air means a thinner fuel/air mixture is drawn into the engine's cylinders. For a non-turbocharged engine, this results in decreased power. For each 1,000 feet of density altitude, a normally aspirated engine will lose approximately 3 percent of its rated power.
Although this doesn't sound significant, at a density altitude of 10,000 feet, the most we can get will be 70 percent power. While this may be fine for cruise, it can make for some hair-raising takeoffs.

To put this into perspective, let's consider a flight in a Cessna 172M from an airport with a 6,000-foot elevation, an altimeter setting of 29.92, and a temperature of 21^{o}C (70^{o}F). Standard temperature at 6,000 feet is about 3.1^{o}C (37.58^{o}F), so plugging these numbers into a flight computer gives a density altitude of 8,021 feet. Since we lose 3 percent of our rated power for each thousand feet above sea level, our normally aspirated engine will only produce 76 percent power (8x3=24). That's all we'll have for takeoff, so we can expect a slower acceleration, longer takeoff roll, and a slower, shallower climb.

Wings Flight School

Using pilot operating handbook (POH) performance charts, which are based on pressure altitude at sea level on a no-wind 21?C day, our 172 at gross weight will have a takeoff ground roll of just over 900 feet, and takeoff distance over a 50-foot obstacle of about 1,700 feet. At our 8,021 density altitude, the same aircraft will require a ground roll of more than 1,600 feet, and more than 2,900 feet to clear a 50-foot obstacle if we've leaned the mixture to give maximum rpm at full power as recommended by the POH. Note the distances at the higher elevation are nearly double those at sea level.

As density altitude degrades takeoff performance, so does it reduce climb performance. Consult the performance charts and examine the surrounding terrain carefully. Before taking off from a mountain strip, ensure that your aircraft, with its performance reduced by altitude, will safely takeoff and climb more quickly than the ground does.

Upon leveling off 2,000 feet above ground level (AGL), we'll find that indeed we do have slightly better cruise performance measured in true airspeed. At sea level, 75 percent power translates to about 112 KTAS (knots true airspeed). But cruising at a pressure altitude of roughly 8,000 feet, we get closer to 120 KTAS. Of course, that's at full throttle, which at this altitude is around 70 percent power.

For landing, we again see the effect of density altitude. Comparing the 172's performance data at sea level and at 6,000 feet, we see the landing distance increase from just under 1,300 feet (over a 50 foot obstacle) with around a 540foot ground roll at sea level to more than 1,500 feet (over a 50 foot obstacle) with an approximate 670-foot ground roll. Of course, this all assumes we do everything perfectly. A little extra airspeed translates to even greater landing distances.

Basic Mountain Flying Techniques

Given this environment, learning to fly in the mountains can be challenging, but it is not impossible or more difficult than learning to fly in the flatlands. It's just different. As with all types of flying, the first rule of flying (mountain or otherwise) is to get instruction from a qualified, experienced flight instructor. Whether you're a zero-time student or an old hand who's never flown in the mountains before, if you don't have specific training in mountain techniques, you could find yourself in a difficult situation without the proper knowledge to safely extricate yourself.

The second rule in mountain flying is to always be in a position where you can descend and turn to lowering terrain at idle power. Follow this important axiom and you'll have a much better chance of living to be an old pilot. Engine failures are not terribly common, but they occur, and the consequence of such an occurrence over inhospitable terrain cannot be overstated. In the mountains, we sometimes operate close to the aircraft's service ceiling, and even minor downdrafts can result in altitude loss.

Wind As Water

Visualizing the wind as water flowing over the terrain can help predict where updrafts and downdrafts will occur, and this helps us decide where and when not to fly. On the upwind side of ridges and mountain ranges, expect an upward flow of air; on the leeward side, expect a downward flow.

Start your climb long before reaching high terrain (and remember that climb performance declines with altitude). A long shallow climb provides better visibility and helps keep your engine cool. Three miles prior to arriving at a pass, plan to be 1,000-1,500 feet above the elevation of the pass to ensure adequate clearance, and to give you the opportunity to deal with any unexpected downdrafts. Although we expect an updraft on the upwind side of the pass, pressure gradients between valleys can cause reverse flows, or "rip tides," at passes, giving us downdrafts where we would normally expect an updraft.

Crossing ridges and passes can be tricky. It demands both caution and your full attention. If you approach a pass or ridge at a 90-degree angle and encounter a strong downdraft, you'll need to turn more than 90 degrees to avoid the rising terrain. Instead, approach ridges and passes at a 45-degree angle, which allows a rapid course change toward lowering terrain.

Understanding What You See

Visual illusions, as well as altimeter error, have caught more than a few pilots, but the clues are there if you watch for them. Don't rely solely on your altimeter for terrain clearance. The venturi effect of wind accelerating over passes can cause altimeter errors in excess of 1,000 feet. Crosscheck it with the vertical speed indicator (VSI) to determine a climbing or descending trend (and remember that VSI indications are not instantaneous; they lag behind actual climbs or descents). Watch the terrain on the far side of the pass. As you approach a pass, increasingly more terrain should be visible on the far side. If not, you're too low, so turn around and climb. Remember, altitude is your friend. After crossing a ridge or pass, depart perpendicular to the ridge line to maximize your rate of departure from the terrain.

Much mountain flying is done following valleys, which lets us take advantage of lower altitudes, the lift found along the valley's downwind side, and the relative safety of better roads and more populated areas. Avoid flying down the middle of a valley - it's apt to have wind shear, eddies, and turbulence. More importantly, it leaves you only half the valley width in which to turn around.

Instead of the middle, fly along the valley's updraft side. Look at your directional gyro and visualize the wind as water to help determine the updraft side. If the side you think should have the updraft seems to have a downdraft, try the other side. If you enter a downdraft, keep the nose down and increase airspeed to get out of the descending air. Although this seems contrary to common sense, most general aviation airplanes don't have enough power to climb out of a substantial downdraft. Fortunately, downdrafts are usually localized, so if you increase your speed, you'll get out of them sooner and with less altitude loss.

Flying In Canyons

Although exciting and dramatic, many mountain accidents have resulted from pilots flying into canyons. It's relatively easy to get disoriented in the mountains; even experienced pilots have become disoriented in familiar terrain and flown up the wrong canyon. This can be a recipe for trouble. Rely on your compass and careful pilotage to keep track of your location. Before flying into an unfamiliar canyon, fly above it and survey the terrain and associated hazards. If you must fly in one, enter it from the high end, and fly down and out of it.

Narrow canyons, those less than two times your aircraft's turning radius, should be flown at a speed greater than V_Y (best rate of climb speed) and on the downdraft side. This leaves you plenty of airspeed for evasive maneuvers, and if you get into trouble, a reversing turn will be into the updraft side.

Turning when surrounded by high terrain requires careful bank and airspeed management. The best technique is a medium bank performed at slow speed. In most aircraft, slow to about V_y, and use the flap setting that corresponds to maximum lift (usually the short-field-takeoff configuration).

NOTE: Check the POH for the appropriate procedures. Turn using a medium (30-40- degree) bank. Keep the turn coordinated and avoid the temptation to steepen the turn or raise the nose if you come close to the terrain, because it compromises safe flying speed.

Operation In Turbulence

Mountain flying and turbulence go hand in hand, and some basic rules for operations in turbulence apply. When encountering turbulence, slow to maneuvering speed (V_a) or less and maintain a level flight attitude to minimize airframe stress. Flying in turbulence can be extremely tiring, but placing one hand on the center of the yoke to steady it and keeping the wings level with the rudder may help reduce fatigue.

Updrafts can increase indicated airspeed, even at idle power. If practical, and airspace, altitude, and terrain permit, maintain V_a or below and let the aircraft climb until the updraft subsides or you fly out of it. Exceeding V_a in turbulence can cause structural damage. (See the Flight Training Handbook, AC 61-21A, page 296, "Load Factors and Stalling Speeds".)

Landings

Part of your preflight planning will include collecting information on the destination airport. But a picture is worth a thousand words. Fly over the airport and familiarize yourself with the terrain at both ends of the runway. This will help you plan a go- around, and it gives you additional information necessary when planning your departure.

Surrounding terrain may make a normal pattern impossible, which can be a problem since the "normal" visual clues may not work with a nonstandard approach.
Regardless of the approach, use recommended airspeeds in a stabilized power-on approach because higher speeds will cause you to float and use excessive runway; long, low approaches are dangerous and should be avoided. Generally speaking, you should plan to land uphill on a sloping runway; landing downhill tends to use more runway, and the brakes may be inadequate for stopping. (Again, learn how from a qualified instructor before trying any new procedure solo because there are many variables involved.)

Your ability to judge altitude and glidepath can be critical. Some mountain strips have one way in and one way out, which means the approach may have a point of no return - a point after which a go-around is not possible due to rising terrain. Many of these runways are short, making touch-down at a precise point essential.

These strips require spot landings. With airspeed and power set, the landing point, or spot, should remain "fixed" in the windshield. If the point starts to "drop" in the windshield, you're too high. If it starts to "rise," you're too low. By maintaining constant airspeed and keeping your "spot" fixed in the windshield with power, you'll fly right to the runway spot and touch down approximately 300 feet beyond it.

Because they reduce landing speed, which must be dissipated during rollout, using full flaps is a good idea. But, following the POH's recommendations, this may not be advisable in crosswinds due to the weathervaning effect it induces. Needless to say, proficiency in short-field and crosswind landings is essential.

Wings Flight School

Takeoffs

Takeoffs from flatland airports are typically based on runway length and the wind. We plan departure paths based on safety and noise abatement concerns. Takeoffs from mountain airports can be much more complicated, and careful planning is a must. In addition to wind and runway length, we must consider several additional factors.

Leading the list is reduced aircraft performance, the penalty of density altitude. This means slower acceleration, longer takeoff roll, and a shallower climb angle. Mountain runways are frequently sloped - another factor that dramatically affects takeoff performance. Generally, each degree of runway slope will increase the takeoff roll by 10 percent.

Terrain will probably dictate our departure path. With decreased performance, you may want to plan your departure in the general direction of lowering terrain. And with a steeply sloping runway, a downhill takeoff may be the only viable option. But again, there are many variables, such as wind direction and possible downdrafts, that must be considered when planning a mountain takeoff. Get qualified instruction before trying it solo, and always check the POH performance charts before attempting any such takeoff! If the numbers don't add up to safety, stay on the ground.

Certain that conditions and aircraft performance will allow a safe takeoff and climb performance, check your engine gauges and airspeed, and keep track of your position along the length of the runway during the takeoff roll. You should have reached 70 percent of rotation speed when you're halfway down the runway. If not - abort the takeoff and rethink your game plan.

Flight Planning

Planning a mountain flight may involve much more than it does for other types of flying. The weather briefing becomes more critical and can dramatically affect your route. Route selection carries additional considerations of terrain, landmarks, proximity of safe landing areas, and communications. We must also consider the emergency equipment we'll carry, and finally, we must consider the passenger briefing.

Weather Briefing

The best time to fly in the mountains is the early morning, when temperatures and density altitudes are lower, and before adverse weather develops. Novice mountain pilots should restrict their flying to day VFR (visual flight rules) conditions. Most general aviation aircraft don't have the capability to fly mountain IFR because of high (often above 14,000 feet) minimum enroute altitudes, and because many are not certificated for flight in known icing conditions, which often exist at the higher altitudes.

Although early mountain weather information can be scarce, get a good briefing before takeoff. The winds aloft information should give you an idea of mountain wave activity. Examine pressure gradients to determine whether there may be unusual flow reversals over passes. Unstable air and forecasts for convective activity are important because these conditions may spawn thunderstorms. In areas where relatively moist air is forced up a mountain, you can expect "up-slope" conditions - fog, clouds, and poor visibility. Finally, if the ceilings and/or visibility are low, find a different route, a different day, or don't go.

Route Selection

Weather naturally influences route selection. Two parallel routes separated by a ridge can have different conditions. While there may be up-slope conditions on one side, smooth, clear conditions may prevail on the other. But while one side may be clear, the valley on the other side may be fogged in.

After taking the weather into consideration, review different routes. Avoid desolate areas. Look at the passes and note their altitudes. Look at the valleys to get "the lay of the land." Find "escape routes" in case the weather deteriorates. Because your aircraft will perform better, which enhances safety, select a route over lower terrain, a route with easily identifiable landmarks and with airports along the way that can serve as alternates. Follow major highways, which ease navigation and keep you close to "civilization" in case of an emergency. In addition to sectional charts, state aeronautical charts, and road, topographic, and recreational maps also provide useful information.

Mark your route on a sectional chart with a highlighter, draw an arrow, and indicate the magnetic course for each leg. This makes a handy reference for pilotage and helps prevent you from turning down the wrong canyon or going over the wrong pass.

VORs (VHF Omnidirectional Range), NDBs (Non-Directional Beacons), and even AM radio stations (if you have an Automatic Direction Finder - ADF) can sometimes be used for mountain navigation, but understand that terrain may restrict their range and reception, so note this information, but don't rely on it exclusively.

Getting exact ground speeds for practical flight planning purposes is difficult. Winds can vary greatly, you may need to divert for weather, or circle to gain needed altitude. These factors greatly affect your average ground speed. For planning, select a ground speed that's between cruise and V_y. This provides a time "cushion" that adds a safety margin in terms of fuel reserves.

You need to be especially conservative with fuel requirements. Un-forecasted weather and circling for altitude can add delays that increase fuel consumption. You may also need to divert to an alternate airport that is some distance away. Always have enough fuel to make an alternate, even if it's the airport from which you departed. I plan on a minimum 2-hour reserve, even if it requires a refueling stop every 90 minutes.

Communications is another flight planning consideration. You'll want enroute weather advisories, on which in-flight decisions will be based, and you'll want to make position reports to Flight Service. Because the mountains affect radio communications, consider options you don't normally think about. Control towers, fixed-base operators (FBOs), remote communications outlets (RCOs), VORs, and other aircraft can be called upon to contact Flight Service, or to relay a message to them. Finding a frequency on a chart is easier on the ground, so highlight them, or write them on your navigation log before takeoff.

Record the airport elevation and runway numbers and lengths for each airport (planned, unplanned, and alternate) you may visit. Consult your POH performance charts and ensure that these facilities are adequate for takeoff and landing under the given conditions, and remember that temperatures will increase during the day, which will increase density altitudes. Give yourself a large safety margin, keeping in mind that published performance data are based on a brand new airplane flown by a test pilot. Generally speaking, your airplane will not perform like a new one, and you'll likely not perform to test pilot standards (and you may not get several chances to attain the best numbers, as test pilots do).

Preflight Briefing

Every flight, regardless of location, should include a careful preflight inspection. But mountain flying requires some additional considerations, such as aircraft loading. For example, put your jacket over the seat back, instead of the baggage compartment, so you can grab it as you exit the plane in an emergency.

Don't limit your preflight to the airplane. Brief your passengers. Ensure they know what to do in an off-field landing, and where the airsickness bags and survival equipment are. (See sidebar.) Show them how to use the radio and activate the ELT (Emergency Locator Transmitter). The student-instructor team should cover the same information in addition to the lesson brief.

Wings Flight School

Safety Considerations

File a VFR flight plan; don't forget to activate it, update it enroute, and close it. The average time for locating a missing aircraft that filed a flight plan is about 38 hours. Without a flight plan, it's more than three days!

A will not begin until after you fail to arrive at your destination. Unless more specific information is available, rescuers must your entire route, which is time-consuming. Making frequent position reports will give rescuers a better idea of where to start looking.

To further aid possible efforts, stay in radio contact with someone at all times possible during a flight. Then if something goes wrong, the word goes out immediately. So use those frequencies on your navigation log, and talk to people - FBOs, Unicoms, control towers, Flight Service, and other aircraft (on 122.75 mHz).

Get enroute weather updates. Unofficial information received over Unicom can be helpful, but Flight Watch (122.0 mHz) provides updated information from pilot reports and local observations. Help your fellow pilots by making pilot reports.

Planning a flight and flying in the mountains may be more challenging than other types of flying, but taking the time to learn how to do it right from a competent, experienced instructor is well worth the effort. You may find that the considerations given to mountain flight plans improve your "flatland" flying and flight planning.

EDITOR'S NOTE: This article is not intended as a home-study, do-it-yourself mountain flying course. Before venturing into the mountains, get instruction from an experienced and qualified flight instructor. To locate one, contact the Accident Prevention Program Manager at your local Flight Standards District Office.

Preparing For Emergencies

When planning a flight over inhospitable terrain, you need to think seriously about emergencies. The National Transportation Safety Board files are filled with reports of successful off-field landings where the survivors died of exposure or other complications. Pilots who expect emergencies are prepared to handle them, so review all appropriate emergency procedures, critical airspeeds, and short- and soft- field takeoff and landing procedures before every flight. In an emergency situation, if you've filed and activated a flight plan, rescue operations typically start within a day, although nightfall or poor weather may hamper these efforts. Without a flight plan, it may be days before anyone even knows that you're missing. In either case, a little bit of survival sense goes a long way.

Your survival equipment should be tailored to the season and the terrain you'll be flying over. Generally speaking, you should carry the clothing and equipment you'd like to have if you suddenly found yourself on a multiday camping and hiking trip there. But don't fool yourself. The mountains get awfully cold at night during the summer, and I've driven through Rocky Mountain snowstorms in August.

Here is a list of some of the survival equipment commonly recommended by experts:

- Water
- Warm clothing & rain gear
- Fire-starting materials
- Tarp, tent, or large "Space Blanket"
- Food
- Sleeping bag
- Signaling equipment: ELT or handheld transceiver, flares, strobe, red carpenter's chalk, heavy-duty flashlight
- Tools: knife, pliers, flex saw, vise grips, axe/hatchet
- Complete first aid kit

Remember that someone other than you may be using the survival kit, so tell your passengers where it is during your preflight briefing and include a survival manual or instructions.

For more information on emergency survival, the following resources are suggested:

- Department of the Air Force, Aircrew Survival, AF Pamphlet 64-5, U.S. Government Printing Office, 1985.
- Auerbach, Paul S., M.D., Medicine for the Outdoors, Little, Brown, and Co., Boston, 1986.
- Anderson, Eric G., Plane Safety and Survival, Aero Publishers, Inc.Fallbrook, CA, 1978.
- Papa Bear Whitmore, Wilderness Institute of Survival Education: Survival Consultant Survival Training Programs, Survival Equipment; 3380 Parfet, Wheat Ridge, CO 80033; (303) 231-0069.

Mountain Flying Resources

For more information on mountain flying techniques, the following references are strongly recommended:

- Geeting, Doug, and Steve Woerner, Mountain Flying, TAB Books, Inc. Blue Ridge Summit, PA, 1988.
- Imeson, Sparkey, Mountain Flying, Airguide Publications, Inc., CA, 1982.
- Pitkin County Air Rescue Group, Box EE, Aspen, CO, 81612; Information packet on mountain flying and routes to Aspen Airport.
- Tips on Mountain Flying, The Federal Aviation Administration, General Aviation Accident Prevention Program. Contact the Accident Prevention Program Manager at your local FAA Flight Standards District Office.
- High Mountain Flying in Ski Country, USA, The Federal Aviation Administration, Northwest Mountain Region, Denver Air Route Traffic Control Center, 1991. Also available through local FAA Flight Standards District Offices.
- A Matter of Survival, Colorado Wing Civil Air Patrol, P.O. Drawer C, Lowry AFB, Denver, CO 80230; (303) 321-3713.

By Robert N. Rossier

Wings Flight School

The Weather Never Sleeps
The air up there

The basics of gas density

The concept of air density can seem pretty abstract when you read about it in a textbook. In fact, most people go through life without ever thinking about air, much less its density.

Standard atmosphere

Altitude	Density
(feet)	(slugs per
0	cubic foot)
1,000	0.002378
2,000	0.002309
3,000	0.002242
4,000	0.002176
5,000	0.002112
6,000	0.002049
7,000	0.001988
8,000	0.001928
9,000	0.001869
	0.001756

Source: Aerodynamics for Naval Aviators

But if you're a baseball player or a pilot, the air's density is a key to performance.

The density of anything is the amount of mass in a particular volume, such as the number of kilograms in each cubic meter of a solid such as wood, a liquid such as water, or a gas such as air. (In American units, density is often described in pounds per cubic foot, which works well enough for ordinary uses. But pounds are a measure of force, not mass. Scientists and engineers use a unit called the slug for mass. Near the Earth's surface, a slug is about 32.2 pounds.)

Unlike solids and liquids, the density of a gas can vary widely. With air, pressure and temperature are the main factors determining density. If the air isn't confined to a container, the density decreases as the temperature rises. Density also decreases as the air's pressure drops.

As anyone who looks at weather maps can tell you, air pressure changes are associated with weather changes.
But the air's pressure decreases much more quickly with increasing altitude than anything the weather does. For instance, getting into an airplane and climbing only 2,000 feet on a day with perfect weather takes you into air pressures that are lower than the pressure in the eye of a strong hurricane.

The "standard" air pressure at sea level is 29.92 inches of mercury, while at 2,000 feet above sea level it's 28.82 inches of mercury. This is lower than the pressure measured by a hurricane hunter airplane in the center of Hurricane Charley on August 13, 2004, about an hour before it hit southwest Florida with strongest winds estimated at 140 mph.

A baseball player aiming for fame and fortune by hitting home runs offers a good look at how the decreased air density of high altitude can help. Aerodynamic drag slows a baseball that's hurtling toward the outfield fence. Drag is the force acting opposite to the direction of an object's motion. You can think of it as the force needed to push aside the air's molecules. The force needed to do this -- drag -- decreases as the number of molecules and their weight decrease. That is, drag decreases as air density decreases.

Wings Flight School

An airplane's engine creates the thrust that balances drag. When a pilot increases power, thrust is greater than drag and the airplane goes faster. (To keep things simple, we're looking only at straight-and-level flight.)

The would-be home run hitter doesn't have a throttle. The energy the bat imparts to the ball is the only thrust that it will ever have.
From the crack of the bat on, drag is slowing the ball down. The lower the air's density, the lower the drag slowing the ball and the farther it will go before falling to the ground.

Higher temperature also decreases drag, but increasing altitude is the biggest factor for baseball players. Jan Null, a retired National Weather Service meteorologist who runs Golden Gate Weather Services in California, calculated how far balls hit with the same force at different fields would go based on air density. Using the elevation (altitude) of different locations, Null calculated that a homer that would travel 400 feet at sea level would go about 408 feet at Atlanta's Turner Field, which at an elevation of 1,000 feet is the second-highest major league ballpark. The ball would travel 440 feet in Denver's Coors Field, where the elevation is just short of a mile. The seats in the 20th row of the upper deck are purple to indicate they are exactly 5,280 feet above sea level.

Air density on the Web

The many useful computations of the El Paso National Weather Service office weather calculator include density altitude under "Pressure Conversions".

To learn more on how air density affects baseball, see this archived story on the Golden Gate Weather Services Web site.

For a look at how air density affects auto racing, see this account at USAToday.com.

Unlike the effect on home-run hitters, low air density decreases the performance of most athletes. As you go higher, the percentage of oxygen in the air remains the same -- around 21 percent. But, since each cubic foot of air contains fewer molecules of all of the gases, each breath brings in fewer of the oxygen molecules that our bodies need to function.

In simple terms, our bodies combine fuel -- the food we eat -- with oxygen to create the energy that powers our bodies, including our brains. An airplane's engine, like your body, combines oxygen with fuel to create power.

As you go higher, the lower drag in low-density air can't make up for the power loss in thin air. Decreased drag also can't make up for an airplane's loss of lift in thin, low-density air.

While the details of exactly how an airplane's wings create lift are complicated, one of the key factors is how many molecules of air's various gases hit the wing each second. Since the air's density affects the amounts of drag, thrust, and lift that an airplane produces, you shouldn't ignore it when you go flying.

Airline pilots, for instance, calculate how much runway will be needed to lift off the ground, and other performance figures, before each flight based on the weather, the airport's elevation, and the airplane's weight.

Such calculations are rarely done for the small airplanes used for flight training,
except under unusual circumstances such as a flight to a high-altitude airport on a hot day, or when taking a knowledge test.

Wings Flight School

This works out well most of the time for most pilots because given the light loads usually carried, the aircraft performance, and the lengths and elevations of runways usually used, the difference between, say, a 60-degree and a 90-degree day at the same airport isn't going to dangerously degrade performance.

During a first flight in hot weather a student might notice that the airplane isn't climbing as briskly as usual, but it still clears the trees at the end of the runway with room to spare. Such routines can lead to dangerous complacency when you fly to an airport at a higher altitude than where you normally fly, on a hot day, and maybe carrying a passenger or two plus luggage.

For this reason, it's a good idea to study the performance charts in the pilot's operating handbook for the airplane you are flying to see how altitude, temperature, and aircraft weight can affect how much runway it will take to lift off, and what distance you'll need to clear a 50-foot obstacle along your takeoff path. Remember that increasing density altitude decreases airplane performance, and decreasing density altitude increases airplane performance.

In most cases, the charts in the handbook enable you to use airport elevation, the temperature, aircraft weight -- and sometimes other factors -- to calculate the distance from the beginning of the takeoff roll to liftoff, and then to clearing that 50- foot obstacle.

Sometimes calculations are done in terms of density altitude, and flight computers normally allow you to calculate this. The concept isn't as difficult as it might seem.

When engineers began designing airplanes early in the twentieth century they needed some firm numbers for air density in order to calculate how their creations would perform at different altitudes. As we've seen, such numbers are moving targets because changes in the weather change the air's density.

The answer was the standard atmosphere, or a listing of figures for temperature, air pressure, density, and other parameters for altitudes from the ground up as high as designers wanted to fly. The standard atmosphere is based on calculations and measurements. Think of it as an "average" atmosphere.

The standard atmosphere table on p. 49 shows only altitudes and air density at those altitudes, using American units.

We can use this table to show what density altitude means. Suppose you were going to take off from a sea-level airport on a warm day. Using the temperature, air pressure, and other factors, you calculate the air's density at that time and place and find that it is 0.002242 slugs per cubic foot.

You'd look at the table and see that this density is found at 2,000 feet in the standard atmosphere. You would say that the density altitude is 2,000 feet. In other words, even though you are at sea level, your airplane would perform as though it were at 2,000 feet on a standard day. This is the density altitude.

You are likely to hear such a figure described as a high density altitude, meaning that the density altitude is higher than the true altitude. But this can be confusing. Most English speakers would think the word high modifies the word density. That is, you might think that the air has a higher density than at low altitudes. But, high really describes the altitude. In other words, the air has a "high-altitude" density.

By the way, the density altitude can be below sea level. For example, if the temperature is 0 degrees Fahrenheit, the density altitude at a sea-level airport could be around minus 4,000 feet.

Unless you take a class in advanced meteorology, you're not likely to ever calculate the air's density. Instead, flight computers or online weather calculators give you the density altitude (see "Air Density on the Web," left).

A baseball player trying to hit home runs doesn't have to do anything different at Coors Field; he just hits the ball as hard as possible.

Wings Flight School

As a pilot, you can't do things the same as you would at a time and place where the air density is high. Instead, you need to understand how the natural world affects your airplane and use that information to make sound decisions.

Jack Williams is coordinator of public outreach for the American Meteorological Society. An instrument-rated private pilot, he is the author of The USA Today Weather Book and The Complete Idiot's Guide to the Arctic and Antarctic, and co- author with Bob Sheets of Hurricane Watch: Forecasting the Deadliest Storms on Earth.

By Jack Williams