The Landing demystified (Tim Brill ATP/CFI)

When the weight exceeds the lift, your airplane will descend and eventually land. Pretty basic!

This is a two part article. In Part 1 we discussed the takeoff. We now discuss the landing.

A Reminder about Airplane Energy

Remember, your airplane needs a minimum amount of energy, call it airspeed, to generate the lift necessary to fly. If you have too much airspeed, you may begin to pull parts off your airplane because you have exceeded its structural limits. This is why your maneuvering speed is so important. Your airplane's "pressure relief valve" is its ability to stall. Anyway, this defines your airplane's flight envelope, (minimum energy to fly and maximum energy that doesn't exceed the structural strength of the airplane) and as long as you stay within the flight envelope everything the airplane does it was designed to do, including stall and spin! Your only real "job" as pilot in command is to stay within your airplane's flight envelope. You still need energy to control your airplane during the landing! It is not just a controlled crash.

The Lift Formula Revisited (My thanks to NASA)

An aircraft's lift capabilities can be measured from the following formula:

$L = (1/2)\ d\ v^2\ s\ CL$

- L = Lift, which must equal the airplane's weight in pounds
- d = density of the air. This will change due to altitude. These values can be found in a I.C.A.O. Standard Atmosphere Table.
- v = velocity of an aircraft expressed in feet per second
- s = the wing area of an aircraft in square feet
- CL = Coefficient of lift , which is determined by the type of airfoil and angle of attack.

So, let's say your airplane weighs 1800 lbs. How much total lift do you need to lift an 1800 lb airplane into the air, a bit more than 1800 pounds. Less than that and we start a descent towards the ground. If we assume the air density is constant, the area of your wing is constant and you cannot exceed the critical angle of attack, really the only variable you have left is velocity. If we maintain a constant angle of attack, and reduce airspeed you will eventually land. Simple.

The Landing Process

Our first step in any landing process is to examine your landing environment. Ensure you have an adequate runway surface. Is it long enough, is it wide enough, what about the wind? What is my go around point? What is my plan if I have an engine failure?

A word on the runway “center line.” Good technique and airplane handling will have you on the runway centerline. But perhaps even more important is to go in a straight line (especially in a tailwheel airplane). Sometimes in a strong Cross wind I will go in a straight, but slight diagonal across the runway, takeoff roll to cut down a bit on the effect of the crosswind. Your rudder usage will keep you in a straight line, so be generous in using them.

Finally, keep your pattern “tight” enough that if you had an engine failure, you can actually glide to the runway. If someone is going too slow in front of you, try to slow down. You don’t need to fly a 747 size traffic pattern in a Cessna 152!

Your transition to landing begins in the traffic pattern. Ideally, when you are abeam (approximately 90 degrees to the left or right) your aiming point, you reduce power, reduce speed, and hold slight forward elevator pressure all the way to your aiming point. Do this and you will never have the dreaded base to final stall spin accident. In my Pitts S2B, I would always elect a 180 degree descending turn to the runway. Never a problem. The real problem is too many pilots fly too large of a traffic pattern. Then if there is any significant headwind or crosswind, they typically end up too low, causing them to incorrectly hold elevator back pressure to limit their “sink,” and then have to add lots of power just to get to the runway. They then arrive at their aiming point (if in fact they make it that far) with a large energy deficit. Sometimes just the opposite happens, they arrive at their aiming point with way too much speed! Either way, a poorly planned approach is not unfixable (although a go around may be appropriate), but now makes the next step in the landing process more challenging. Remember, it is a process, not an event. Lots of small changes early will always be better than one large change done too late. If you do not like what you perceive is happening, don’t hesitate, go around!

A word about “mush”

As the pilot you have control over the angle of attack, but not the critical angle of attack. This is a design feature of the airplane. The critical angle of attack also is the point at which the airplane will stall. Ominous words for saying the airplane is now generating drag faster than lift, and as such its aerodynamic behaviour changes, and so does how the pilot controls the airplane. Pilots are trained to recognise when you are getting close to the critical angle of attack, and to promptly recover by adding forward elevator pressure, or at least relaxing the back elevator pressure to decrease, or lower, the angle of attack below critical. There are many aerodynamic and mechanical clues that a pilot is trained to use to make this prompt and correct control surface input.

Aerodynamic “mush” is one such clue. Remember how at cruise just a small control deflection causes the airplane to respond? When the airflow over that same control surface is now reduced, a much bigger control deflection is now necessary for the same response as at cruise. This bigger required control input is called “mush,” and most frequently happens at landing. Yup, you ran out of energy and now come crashing down on the runway!

Hot Days and High Density Altitude

Remember our lift formula. If the density were to suddenly decrease, as is often the case close to the runway on very hot days when the tarmac is hot enough to cook an egg, you can suddenly lose lift, causing a very hard landing. The solution of course is to add just a bit of power to maintain your airspeed, but often pilots either don't recognize this issue, add power too late, or even add too much power. Expect this issue on very hot days. Keep in mind also that adding power may pitch your nose “up,” changing your landing site picture.

Your airplane will eventually come down on all three wheels. When it is on the ground, notice what that “picture” looks like. Where is the nose in relation to the horizon? Look at the wings in relation to the horizon. This is your landing site picture. If you land with your nose significantly “higher” than necessary, you will land on two wheels. Now, having said that, it is actually a preferred technique in tricycle gear to land with the nose “high.” This helps protect the nose wheel from structural damage and adds a bit of “aerodynamic” braking. The nose wheel will eventually come down when your airplane runs out of energy.

Go Around

If you ever question the outcome of your landing, just go around! Assuming you have fuel, better safe than sorry. When you decide to go around, go around. Add FULL power and CLIMB. Systematically eliminate all the drag items, like flaps and wheels (in a retractable airplane). Once you have a positive rate of climb (and you are at your IFR missed approach point), you can begin your turn and get back into the traffic pattern.

Slow flight down the runway

Probably the best way to perfect your landings, especially cross wind landings, is to just fly down the runway in "slow" flight. Of course, each pass will then require a go around, so you get to practice them as well.

First identify your aiming point. That is not where your wheels will touch down, that will happen beyond the aiming point. Your aiming point is a point that you will fly your pattern in relation to. Just as an idea, I typically pick a point a bit down the runway. Place that point in your windscreen. If you are a bit high, you reduce power. If you are low you have to add power. Try to never get caught in being too low, where you have to add lots of power just to make it to your aiming point. It is safer to stay a bit high and reduce power as you get closer to your aiming point.

Ok, you are finally over the runway. Here begins the most underutilized step in the landing process. You now need to get control of your airplane flying down the runway in a straight line. Notice I did not say "center line." That is the goal, but sometimes not advantageous. Think about slightly raising the aircraft nose and adding a bit of power. Think fly down the runway in "slow flight" Relax. Wiggle your feet. Do not rush. This "trick" alone will most likely put you in the correct landing attitude. If you think you are running out of runway, no problem, add power and go around. Get used to controlling your airplane close to the ground. When you want to land, keep reducing the power and/or increasing the elevator back pressure and, eureka, you land. Of course there are some subtle differences in soft field, short field, and crosswind landing). Regardless, be more aware of your landing site picture. The attitude is always correct, your airspeed indicator always has a slight "lag" time. When I train students in my Super Decathlon, I sit in the rear seat and cannot easily see the airspeed indicator. But, I have memorized the site picture and fly the proper attitude. Oh, and when I do my airspeed is constant and typically spot on the POH recommendation. Another eureka moment
!crosswind and normal landings, but they all require you first have control over the runway.

As stated, the “get control and fly your airplane in a straight line down the runway” step in the landing process is often overlooked. Why, simply put, pilots rush the landing. Not rushing will improve all your landings, especially in tailwheel airplanes. A word on the correct “landing attitude.” When you sit in your airplane on the ground, look at your site picture. Memorize it. All 3 wheels are on the ground. You takeoff from this position and you eventually land in this position. If the nose is significantly “lower” or “higher” than this site picture, you will not land on all 3 wheels at the same time. Now, in a tricycle gear, you normally want to hold the nose wheel off the ground as long as you can, with a slightly nose high attitude. This is a good technique to protect the nose wheel itself. In a tailwheel, you typically want to land all three wheels at the same time (a 3 point or full stall landing) or perhaps a slightly nose low (wheel landing) or tail low (soft field or short field landing).

A word on using your elevator and Aileron

Next, a word on your elevator and aileron. We now know to keep wiggling your feet. That is the single most important control input you can make in a tailwheel airplane. But what about the aileron and elevator? Simply put, pilots typically “overcontrol” the elevator and aileron inputs, and, you guessed it, don’t use enough rudder. First the aileron. Even in a significant crosswind, use the least amount of aileron you need. That is where flying down the runway in slow flight before you land really helps. Instinctually, you will use the least amount of aileron you need, which will limit the “roll” component (aileron-roll, is a head to hip movement of the nose of the airplane) and, among other things, make it a bit easier for your brain to evaluate what is happening (an “illusion” when you wrongly combine the roll and yaw inputs). Once you are on the ground in a crosswind, you may have to add more and more aileron to prevent the wind from “lifting” a wing, so keep some aileron in reserve for use when you really need it. What about the elevator?

Again, pilots typically overcontrol the elevator (elevator-pitch, is a head to foot movement of the nose of the airplane). In the landing flair the initial elevator input is typically too much, too hard, too soon (rushing), which causes the aircraft to balloon, then unfortunately followed by no input at all, so our intrepid airplane comes down in a very “hard” landing. So, in a similar input like our rudder, be proactive, don’t react. Rudder, just keep wiggling your feet. Elevator, try this technique: a small, smooth elevator back pressure input, then stop, don’t pull, don’t push, just stop moving the elevator control. Then another “quick” elevator aft input, stop, Then another, stop, and another and keep going until the elevator is full aft. I sometimes describe it as a “ratchet” method. No balloon, and if you make your elevator inputs ``quick” enough, no bounce. In a perfect world, your power will be idle, elevator full aft and the and the 2 main landing gear, or all 3 wheels in a tailwheel, will touch down at the same time, a picture perfect 3 point landing. Of course your feet are still wiggling, correct?

Special Landings - Soft Field

Our discussion so far is pretty much the typical “normal” landing process. So now let's look at some differences in soft field, short field and cross wind landing procedures.

As the name implies, in a soft field you want to land softly. This is done by landing with a bit of power. This is when slow flight down the runway can help. Raise the nose, get control, add a bit of power, fly down the runway, then slowly reduce the power until your two main landing gear touchdown. You will be in a nose high attitude to protect the nose wheel and will still have a few hundred rpm. In a tailwheel airplane a slight tailwheel low landing is preferred. On some aircraft, partial flaps may also be recommended. In other words, be patient and don’t rush!

Special Landings - Short Field (Confined Space)

This is your maximum performance landing. It is a steep approach and hard landing. The idea is to start a bit high in your final approach, give up altitude for airspeed, fly your POH recommended airspeed to your aiming point, power idle, a somewhat aggressive pitch “up”and typically a hard landing. Once you are on the ground, you are not flying anymore!

Remember to start your descent at the recommended airspeed, it can be a steep descent. Then, when over your obstacle, you gently lower your nose, reduce power, and continue your descent to touchdown. It is a power off landing (unlike the soft field landing, which is typically some power on)

Special Landings - Cross Wind

The cross wind may affect your ability to maintain directional control of your airplane. Remember, directional control is basically your rudder. If you exceed your airplane's maximum, or demonstrated, crosswind component (that combination of wind speed and wind angle) you will lose directional control. So find another runway better suited to your airplane, or just wait until the wind decreases. Keep in mind the gust factor, which may momentarily place you in that realm of no control.

This is where slow flight down the runway will help. If you cannot fly down the runway, you will have a big problem attempting to land. So don't be in a rush. Fly down the runway, and if it feels comfortable keep reducing the power until you land.

Otherwise, the only real difference is in the use of your ailerons to keep the wind from "lifting" the wing closest to the wind direction. At higher speed, use less aileron deflection into the wind. As your ground speed decreases, you can add some of the aileron deflection.

On Your final approach, use the crab method or forward slip method (preferred) to maintain the extended runway centerline.

Conclusion

If you follow a good landing process: get to the runway, get control of your airplane over the runway going in a straight line, and finally, by being more proactive with your throttle, elevator and rudder inputs, land your airplane, your chances of having a problem is negligible. So, to recap, be proactive, don't rush, make constant short elevator aft inputs, and keep your feet dancing on those rudder pedals

Your landing is a process and, again, should not be rushed. Your airplane will land when it's ready to do so, and not before. Don't be in a rush! Be aware of the forces acting on your airplane and "separate" when practicable. Remember, the airplane will only do what you tell it to do, it's not magic! Plan your flight and then fly your plan.

Resources

https://www.grc.nasa.gov/www/k-12/WindTunnel/Activities/lift_formula.html

https://www.grc.nasa.gov/www/k-12/airplane/lifteq.html#:~:text=The%20lift%20equation%20states%20that,times%20the%20wing%20area%20A.&text=For%20given%20air%20conditions%2C%20shape,Cl%20to%20determine%20the%20lift.

https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/media/10_afh_ch8.pdf

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