Normal Approach and Landing

Objective	
To ensure the applicant learns the purpose of and can exhibit a clear understanding of the normal approach and landing maneuver and how to make safe, controlled landings in a variety of wind conditions.	
Purpose	
What goes up of course must come down, and being able to land is a critical skill for pilots to develop. Learning proper landing techniques will put together several skills that pilots have already developed, such as slow flight, ground reference maneuvers, and stalls.	

Schedule	**Equipment**

• **Ground Lesson**: 15 minutes
• Initial
  ▪ **Flight**: 40 minutes - *Introduction to Landings*
  ▪ **Flight**: 20 minutes (per lesson) - *Practice*
• Solo
  ▪ **Flight**: 20 minutes (per solo flight) - *Improve Proficiency*
• Pre-Checkride
  ▪ **Flight**: 20 minutes - *Demonstrate Proficiency*
• **Debrief**: 10 minutes (*per flight*)
	• Airplane POH and Checklist
	• Whiteboard / Markers (optional)
	• Model Airplane (optional)

Student Actions	**Instructor Actions**
• Ask any questions, receive study material for the next lesson. • Watch linked video. • Review listed references.	• Deliver the ground lesson (below). • Demonstrate the maneuver in flight. • Debrief after each flight.

Completion Standards

- **Ground**: Student can explain the purpose of the maneuver and how to execute it properly.
  - Can explain crabbing, sideslip, crosswind technique, a stabilized approach, the role of flaps, and how to fly behind the power curve.
- **Flight**: Student can perform the maneuver to the applicable ACS standards.
  - Performs a stabilized approach at published approach airspeed (or 1.3 Vso) +10/-5 knots.
  - Touches down safely at a designated touchdown point -0/+400 feet (-0/+*200 feet for Commercial*).
  - See expanded Completion Standards below.

References

- ERAUSpecialVFR - “Normal & Crosswind Approach & Landing - Lesson 1”
  - YouTube - https://www.youtube.com/watch?v=DxbcyBjFiSg
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 9, Page 2-10 [Normal Approach and Landing], Chapter 9, Page 15-20 [Crosswind Approach and Landing], Chapter 9, Page 30-37 [Faulty Approaches and Landings]
- FAA-H-8083-25C (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 5, Page 9-10 [Avoiding Wake Turbulence], Chapter 11, Page 19-28 [Performance Charts]
- FAA-S-ACS-6C (Private Pilot ACS) - Area IV Task B
- FAA-S-ACS-7B (Commercial Pilot ACS) - Area IV Task B
- FAA-S-ACS-25 (CFI ACS) - Area VII Task B

Ground Lesson Outline

- Landing brings together the fundamental skills
- Airplanes fly with the air
- All landings begin with the approach
- Airspeed control and trim
  - Behind the power curve
  - Energy management
- The role of flaps
- Importance of a stabilized approach
- The roundout and landing flare
- Estimating glide path
  - Aim point vs touchdown point, VGSIs / VASI / PAPI
- Crabbing Isn’t Enough
- Sideslips / Crosswind Technique
- Importance of holding crosswind corrections
- Go-Arounds
- Landing performance
  - Density altitude
- Wake turbulence / Wind shear
- Safety considerations
  - Use of checklists
  - Visual traffic scanning, Runway incursion avoidance
  - Windshear, Tailwinds, Wake Turbulence, Runway surface conditions
  - Proper coordination, stall risk, Be prepared to go around
- Maneuver Description - step-by-step
  - Entry position, airspeed, etc.
- Expanded Completion Standards

Common Errors

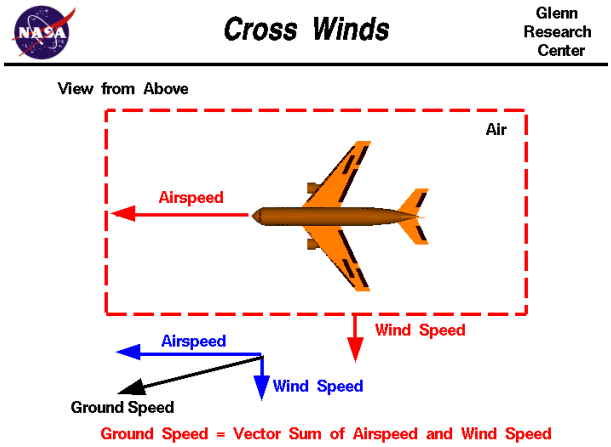
- Improper use of landing performance data and limitations.
- Failure to establish approach and landing configuration at appropriate time or in proper sequence.
- Failure to establish and maintain a stabilized approach.
- Inappropriate removal of hand from throttle.
- Improper procedure during roundout and touchdown.
- Poor directional control after touchdown.
- Improper use of brakes (ASEL).
- Failure to ensure receipt and acknowledgement of landing clearance.

- Failure to review airport diagram for runway exit situational awareness to avoid a runway incursion after landing.

Ground Lesson Content

- **Landing Brings Together The Fundamental Skills** - Landings are perhaps the single most well-known maneuver to both pilots and non-pilots alike. Every flight ends with a landing, but a properly executed landing combines many other fundamental flying skills and involves many more elements than it first appears. Pilots must contend with the wind, changing aircraft configurations, flying at low speed near the ground, as well as requiring knowledge of airplane performance, air traffic control procedures, and many other items.
- **Airplanes Fly With The Air** - It may seem silly to state something so obvious, but it is crucial to understand. Air is always moving, and airplanes are moving within it. When a student pilot watches other airplanes land, it is hard not to notice that their noses are almost never aligned with the runway. They seem crooked.

  - Although airplanes generally fly straight courses through the air, when the movement of the air is added, these courses are different across the ground. **The *ground track* of an airplane is the combination of it's *airspeed (speed through the air)*, *heading (the direction it is pointing)*, and the *wind speed*.**

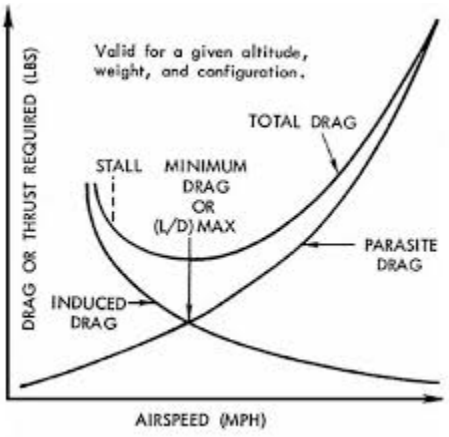


  - **Almost all landings are *crosswind* landings.** There is usually at least some component of wind which is side-to-side relative to the runway. However, because airplanes fly with the air,

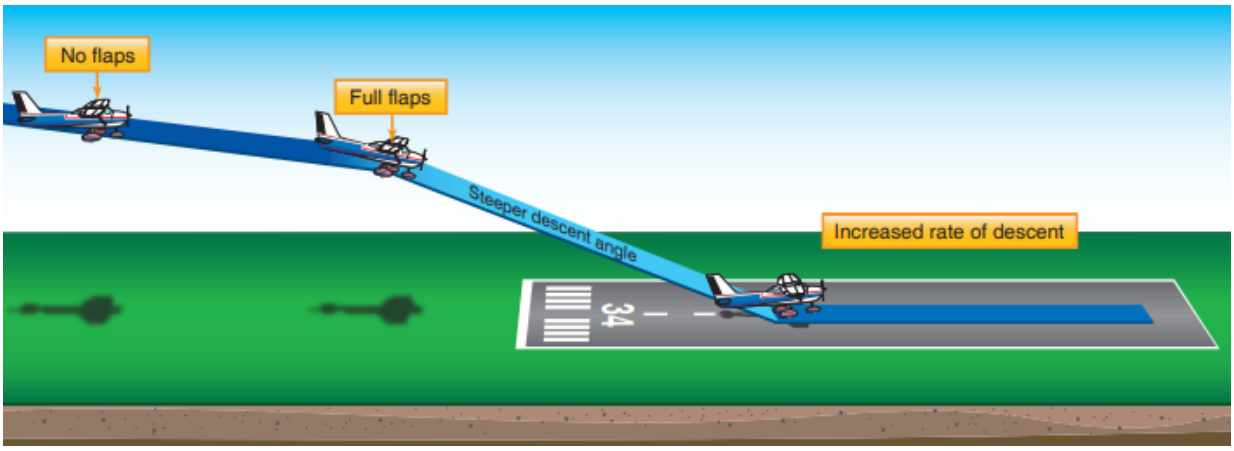
they usually want to take off and land *into the wind*, as much as possible, to avoid side-to-side winds or tailwinds.

- In order to land on runways, which are never moving, in winds, which are always moving, airplanes need to apply a correction to fly a particular course across the ground and align with them. This is usually accomplished by *crabbing* the airplane. That is to say, flying the airplane towards the wind direction, such that the airplane's ground track follows the runway.

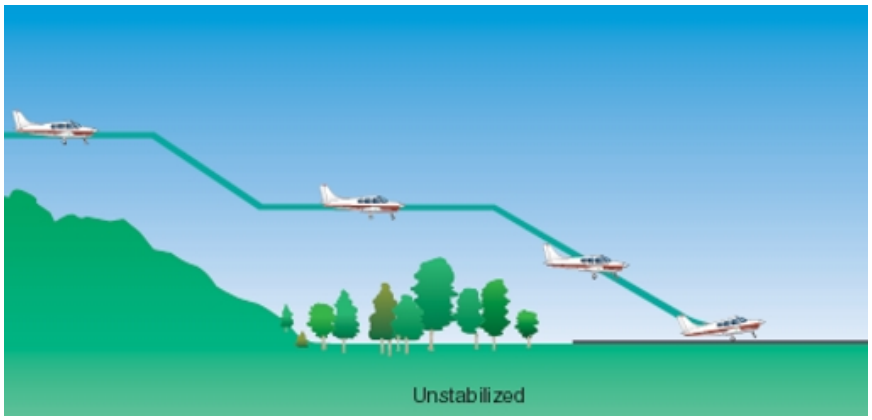
- **All Landings Begin With The Approach** - When preparing to land, the airplane must descend, aligned with the runway. This is nothing more than a constant-airspeed descent. Usually approaches are flown at a speed published for the particular model of aircraft, called the *approach speed*.
- **Airspeed Control and Trim** - When approaching to land, it is important to be aware of the proper approach airspeed. This will often be specified by the POH, but otherwise airspeed on final approach should be no higher than 1.3 x Vso (stall speed in the landing configuration), and in landing configuration (usually full flaps). **It is important to use the elevator trim to hold approach speed throughout the maneuver!**
  - **Behind the Power Curve** - When flying at approach airspeeds, it is important to remember that the airplane will be *behind the power curve*. The power curve represents the amount of power required to maintain a given airspeed without accelerating. This is at a minimum when the amount of total drag is at a minimum.
    - Airspeeds below the minimum drag speed (the best glide speed) are sometimes called the *region of reverse command*. This is because any increase in pitch, and therefore angle of attack, will result in more total drag, which will *increase* the rate of descent.
    - When behind the power curve, in order to control descent rate and glide path, the first action must be to increase or decrease the throttle! **Add or remove power to control the descent, and pitch to maintain airspeed.**
    - It is useful to think about approaches in terms of **Energy Management**, where there is a fundamental difference between a *High Energy* and *Low Energy* approach, as these must be managed very differently.
      - See the lesson on *Area 10 (X) - Task B - Demonstration of Flight Characteristics at Various Configurations and Airspeeds* for more details on energy management.



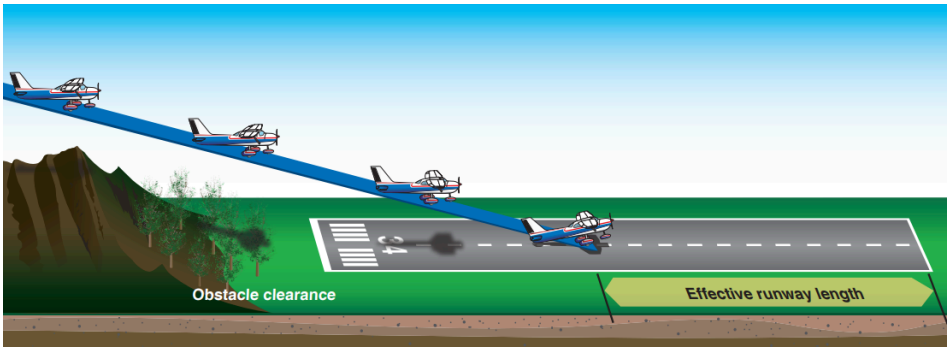
- **The Role of Flaps** - It is normally desirable to descend a bit more steeply than normal to avoid obstacles on final approach. *Flaps* are one tool for accomplishing this. Flaps add additional lift, but they also add additional **drag**. This will result in the airplane flying a *steeper descent angle* than it otherwise would for the same approach airspeed. This has the additional benefit of allowing for better visibility over the nose when at very low airspeeds, like during landing.



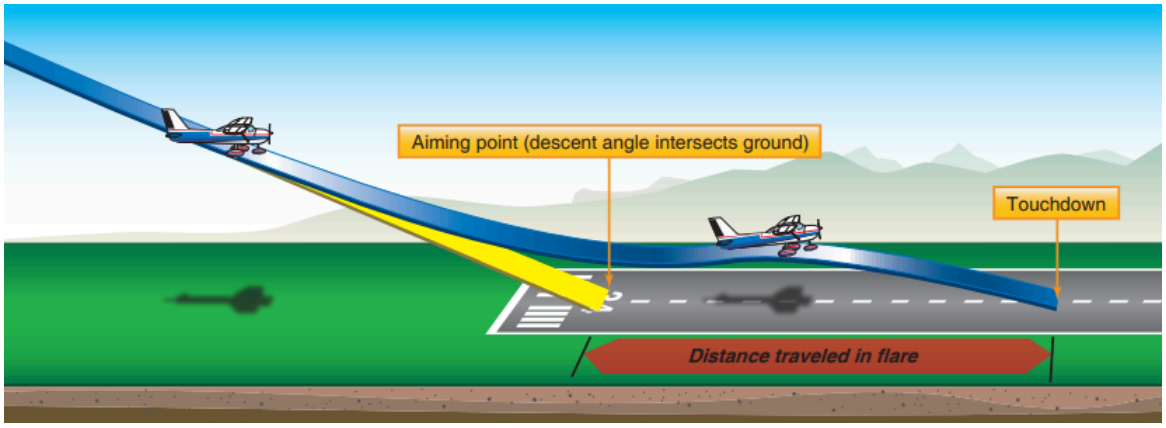
- **Importance of a Stabilized Approach** - As with all landings, the quality of the landing begins with the quality of the approach. It is critically important to maintain a *stabilized approach*.
    - **Unstable approaches are a leading cause of accidents and incidents during landing!**
    - A stable approach should involve smooth, gentle pattern turns, while maintaining the proper approach airspeed and avoiding dramatic forward slips or other maneuvers the entire time. It is important that the airplane be fully configured to land and flying at approach speed, and at a stable rate of descent, at least ½ mile before reaching the runway threshold. Generally, the approach should be stabilized before reaching 400ft AGL. A stable descent is often called a *glide path*, to indicate that it's usually similar to a gliding descent.



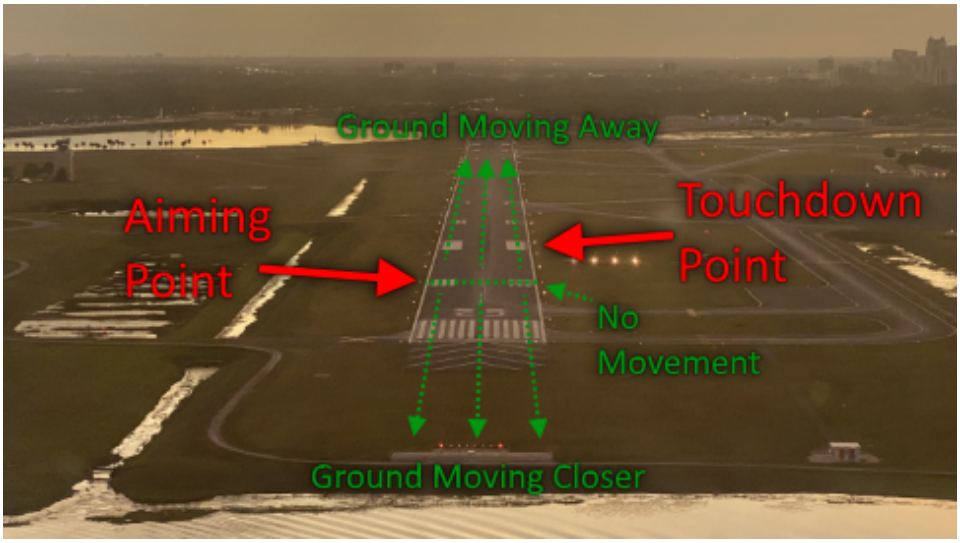
- Even though obstacles on final approach, such as terrain or trees, may require a steeper descent, it is still preferable to fly a *stabilized approach* that will clear obstacles, rather than stepping down or otherwise flying an unstable approach. **Final approach should be flown in a *stable* descent, properly aligned with the runway or landing area!**



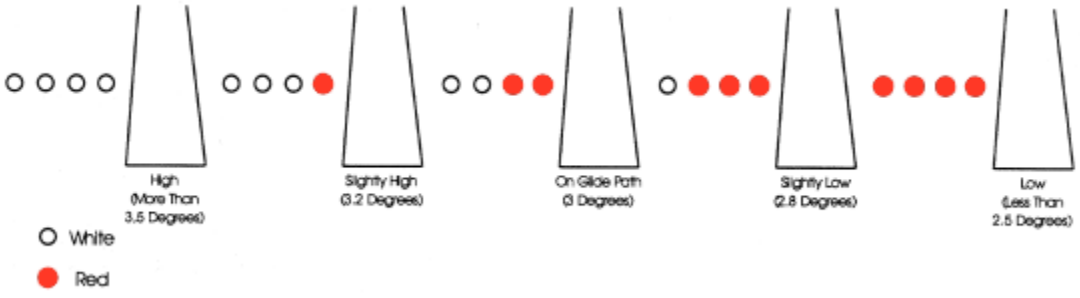
- **The Roundout and Landing Flare** - As the airplane nears the runway, at some point the pilot will need to level off to slow the descent rate and fly close to the runway. This is called the *roundout*. At this point, the engine power is reduced and the airplane will begin to descend gently. The pilot uses back elevator pressure to raise the nose and increase the angle of attack and slow the descent. This is called the *landing flare*.
  - The ideal landing happens with the airplane aligned with the runway, the nose slightly high, and the airspeed just above the stall speed. Landing with lower speeds increases safety by decreasing kinetic energy that must be dissipated, and reduces wear on brakes.
  - As the airplane approaches the runway on final, the pilot should identify a point before the desired touchdown point and use it as an aiming point. As the airplane reaches the aiming point, a normal roundout and flare can be conducted, such that the airplane touches down at the touchdown point. **Aiming at the touchdown point would result in landing long**, because it does not account for the landing roundout and flare.



- **Estimating Glide Path** - In order to master landings, being able to consistently land on the desired spot is important, so pilots must develop their skills in visually estimating the airplane's glide path. This begins with finding an aiming point which is just before the desired touchdown point, to account for the roundout and flare. When in a stable descent, if the aim point is *moving away*, the landing will be short. When the aim point is *moving closer*, the landing will be too long. It is crucial to pay close attention to the movement of the aiming point and make the appropriate corrections.

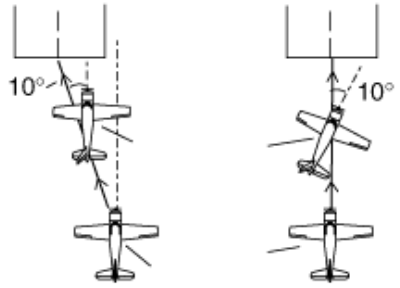


- Some runways are equipped with Visual Glideslope Indicators (VGSIs), and when available they are a great tool for judging the glide path



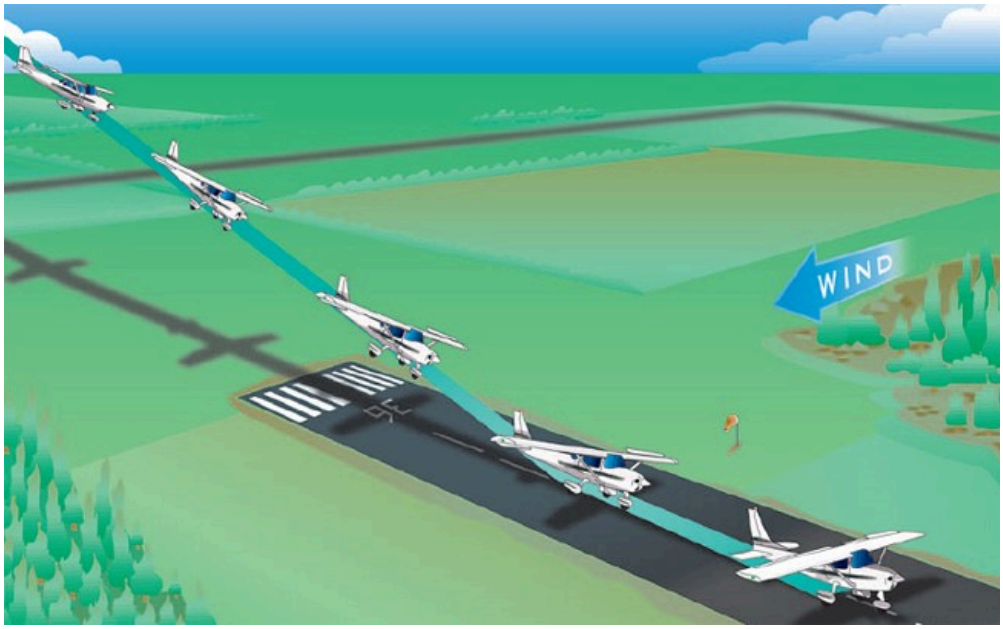
- Pilots should conduct all landings to hit a designated spot, whether or not they are performing a high-performance landing. During the roundout and flare, the pilot should hold just enough back pressure to keep the airplane from touching down until the desired touchdown point is reached.

- **Crabbing Isn't Enough** - Although airplanes can crab into the wind to align with the runway, eventually they need to point in the same direction as the runway as well. Airplane landing gear are just wheels, and just like a car or any other vehicle, they need to point in the direction of travel. **So as an airplane prepares to touch down, its wheels need to align with the runway.**
- **Sideslips** - It is possible to fly an airplane such that it's nose points in one direction, but it flies through the air in a slightly different direction. This looks like a slight sideways motion (relative to the air), and is called a *sideslip*.
    - In order to touch down safely, airplanes must enter a sideslip where the sideslip is moving towards the wind. The sideways motion will be 'canceled' by the wind, and it will result in the airplane flying straight down the runway.
    - Sideslips happen when an airplane is banked, but the *rate of turn* is insufficient for the bank angle. Consider a normal banked turn, with the ball centered. The airplane will have a rate of turn which is related to the bank angle--*more bank, more rate of turn*. Normal turns require rudder to maintain the ball in the center.
    - **If, instead of applying rudder in the direction of the bank, the pilot does not use the rudder at all or applies rudder opposite the bank, the airplane will enter a sideslip.**
    - When in a sideslip, the airplane generally wants to return to normal flight, and pilots will have to hold opposite aileron and rudder controls to remain in the sideslip. This is called a *cross-controlled* condition.

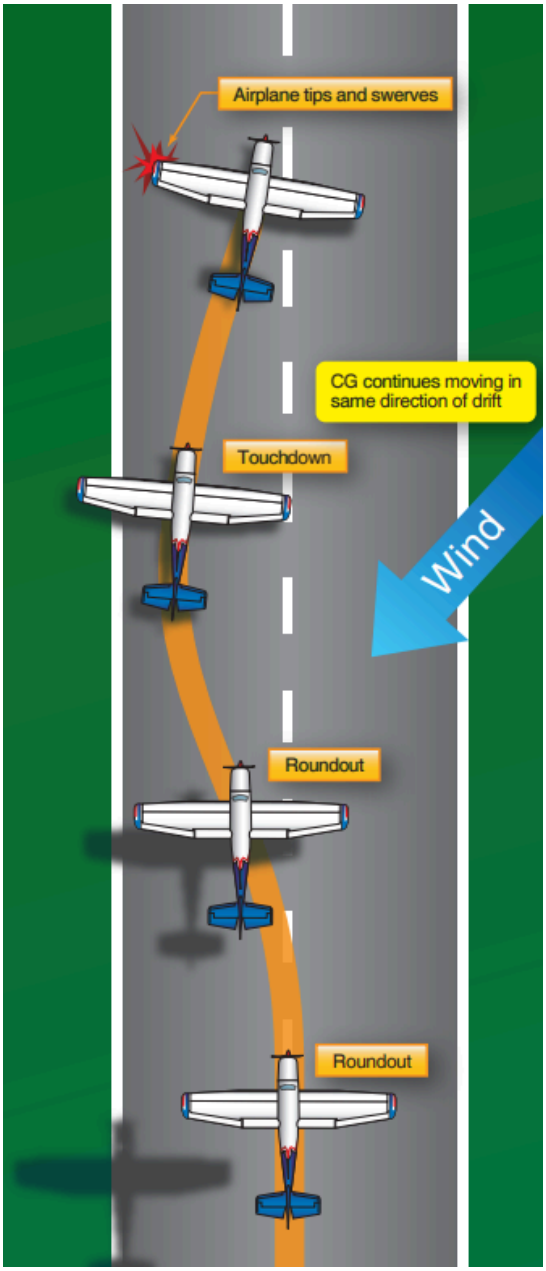


The side slip. The forward slip.

- **Crosswind Technique** - Pilots can use their knowledge of sideslips to land in crosswinds:
    - The pilot estimates the ground track and *crabs* into the wind if necessary to stay aligned with the runway.
    - Once the airplane nears the runway, the pilot transitions into a sideslip by 'crossing the controls', with the aileron *into the direction of the wind*, which aligns the airplane with the runway and keeps the airplane on a straight ground track to the runway. This is called *crosswind correction*.
    - Because of the sideslip (and bank into the wind), **the main landing gear to the side of the wind (the *upwind* wheel) will be lower than the other main landing gear (the *downwind* wheel).**
    - The pilot retains the sideslip through the roundout and landing flare, and touches down first on the upwind wheel, then the downwind wheel, then the nose gear, with no side-to-side motion.
    - It is important to realize that **during a sideslip, the airplane is being flown intentionally *uncoordinated***. The ball will not be in the center.



- **Importance of *Holding* Crosswind Corrections** - If the airplane has any side-to-side motion when it touches down, it will tend to skid and skip along the runway, and **can lead to a loss of control**. This is because the airplane's center of gravity will tend to keep moving in the same direction until correction is applied or until friction has stopped the motion. **Landing gear are not designed to stop sideways motion!**
    - Even in landings where the pilot has applied crosswind corrections, side-to-side motion can develop during the roundout and flare, as the airplane slows. **As the airplane slows, more crosswind correction will be required to achieve the same result.**



- **Go-Arounds** - If it ever looks like the landing may be unsafe, or won't be successful, the safest course of action is usually to *go around*. This means to apply full power, and climb away from the runway and return for another attempt at landing. **It is critical that pilots are always primed for the possibility of a go-around!**
- **Landing Performance** - Determining exactly how much distance will be required for the landing is crucial to ensure the chosen runway will be long enough to make the landing safely. An airplane's landing performance is highly dependent on several changing factors, such as **weight, wind, and density altitude.** Aircraft performance at heavier weights or higher altitudes is greatly reduced.
    - *Density altitude,* which is a correction for atmospheric conditions, is the altitude that an airplane 'feels'.
    - At higher altitudes or on hot days, the density of the air will be less and therefore the airplane will need to move more air to stay aloft. Because the airspeed indicator is also affected by density altitude, it will show the same values, however the true airspeed will be higher.

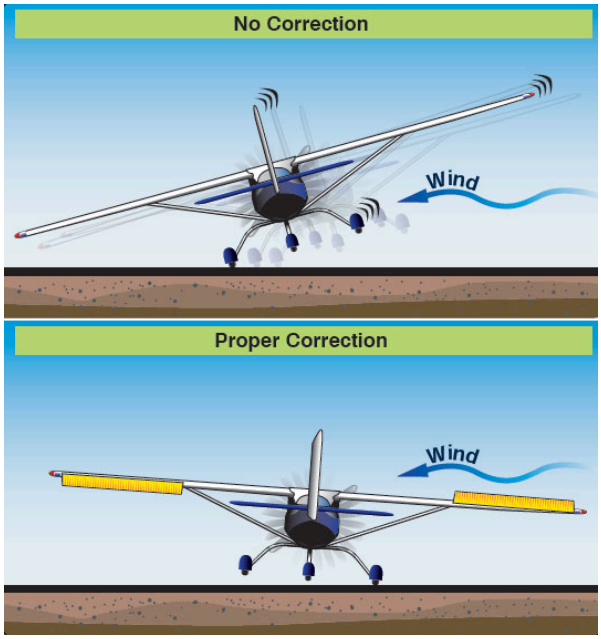
    - **The difference between field altitude and the density altitude can be significant!**
        - See the related lesson on Density Altitude.
- The POH for every aircraft will contain performance charts that detail how many feet of landing distance is required for various weights, winds, and weather conditions. It also prescribes an airplane configuration that should be used.
- **Wake Turbulence** - Small airplanes are particularly vulnerable during takeoff and landing because they share the same runways as much larger, heavier aircraft. These aircraft can leave dangerous vortices behind them, called *wake turbulence.* These vortices begin at the wingtips of the heavier aircraft, tend to move with the wind, and gradually move apart and descend. **Therefore it is critical that when departing behind larger, heavier aircraft, sufficient time (usually 1-2 minutes) is allowed to pass in order to allow the wake turbulence to dissipate.**
    - When landing, wake turbulence of preceding airplanes can be avoided by remaining *above* the approach path of the heavier airplane.
- **Wind Shear** - Small aircraft are also particularly vulnerable to shifting wind directions, called *wind shear*. Because they are generally underpowered and cannot climb rapidly to safety, if an airplane is flying into a 10 knot headwind that suddenly dissipates or changes direction, it may end up in a situation where it descends rapidly and unexpectedly, and the angle of attack may increase to that of a stall.
    - When landing, large fluctuations (more than 5 knots) on the airspeed indicator are a warning sign of possible wind shear. **If you see large fluctuations in the airspeed indicator, go around!**
- **Safety Considerations**
    - As with any landing, the **use of checklists is important**. Before beginning the maneuver, the before landing checklist must be completed. After landing and rolling out to a safe point clear of the runway, the after landing checklist should be completed.
    - **All landings require caution for powerlines, tall trees, or other obstacles on final approach which may be near the runway environment.**
    - It is crucial to not become so focused on the landing that an unsafe situation is created. Maintain situational awareness, make appropriate radio calls, and ensure that landing clearance is obtained before landing. **Vigilance must be maintained after landing to avoid taxiing onto any intersecting runways beyond other hold short lines.** If there is a control tower, do not forget to contact ground control for taxi clearance after landing, and at uncontrolled fields, clearly communicate your taxi intentions on the radio. Remember that uncontrolled fields often have no-radio (NORDO) pattern traffic, so **always visually verify the runway and final approach path is clear!**
    - Maneuvering in the pattern at low airspeed creates a risk of a stalling situation. **If the stall warning sounds before the landing flare, go around!**
    - Except in the sideslip immediately before landing, approaches to land should be flown coordinated to reduce the risk of a stalling situation.
    - When executing any landing, there should be a point identified (*no further than the first 1/3 of the runway*) beyond which if the airplane has not touched down you will go around. If any unsafe situation develops, such as excessive ballooning or being blown off runway centerline, go around! **Always be prepared to go around!**
    - **Windshear, Tailwinds, Wake Turbulence** - During takeoffs and landings, we are operating near the ground at low speed. Pilots should exercise caution if there are indications of

windshear, pay attention to situations where wake turbulence will be a factor. Additionally, taking off or landing with a tailwind creates a much higher ground speed, lengthening the ground roll, and increasing the danger.

- **Runway Surface Conditions** - If the runway is wet or icy, it can be quite slippery, particularly in the touchdown zone where many preceding aircraft have deposited rubber. Exercise caution in these situations!

Maneuver Description

- **Selecting a Suitable Runway** - Select a runway that will allow landing into the wind, or with a manageable crosswind.
- **Selecting a Touchdown Point** - Select a prominent feature on the runway that is easy to identify from the downwind leg, and explicitly state it. Features like 1,000 foot markers, touchdown zone markers, or runway numbers are good choices. Until proficiency is developed, select a feature that is not directly at the start of the runway, in case of landing short.
- **Entry Position and Altitude** - The maneuver should be entered on a normal downwind leg, abeam the touchdown point, at normal pattern altitude.
- **Entry Airspeed** - Begin this maneuver at a normal traffic pattern airspeed, usually around 90 knots.
- **Checklists** - Pilots must perform a before-landing checklist before beginning the maneuver, and an after-landing checklist after taxiing safely clear of the runway, for full-stop landings.
- **Airspeed** - Airspeed should be kept at the approach airspeed designated by the POH, or slightly higher (add half the gust factor) to account for gusting wind conditions. *Be vigilant about maintaining airspeed, and if the stall indication is heard at any point before the final landing flare, discontinue the maneuver and go around!*
- **Bank** - Since this maneuver takes place in an airport traffic pattern and involves maneuvering at low speed and at low altitude, the bank angle should be *less than* **30 degrees**.
- **Approach Path** - Fly a normal, well-defined base leg and final approach segment. Avoid cutting the corners or overflying the final approach course.
- **Coordination** - The maneuver should be flown in coordinated flight. Attention should be given to proper rudder input during turns.
- **Touchdown** - Choose an aiming point such that the airplane will land *at, but not before*, the selected touchdown point. The landing should be at a proper nose-high pitch angle (*not on the nosewheel-- do not force it!*), safe, and under control. Positive aircraft control must be maintained at all times! **Apply *and hold* proper crosswind corrections to avoid sidewards drifting.**



- **After Touchdown** - Apply aerodynamic and wheel braking if making a full stop landing, or if making a touch-and-go, reconfigure the airplane for takeoff and apply full power promptly.
- **Be Prepared to Go Around!** The approach may not work out and a go-around is very possible. Be prepared to execute a go-around if needed.
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper management of the approach path. *Monitoring for other traffic is especially critical when performing this maneuver at uncontrolled airfields.*

Expanded Completion Standards

- The pilot can explain the purpose of the normal landing maneuver and how wind and other factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
    - Pilot selects a runway suitable for the weather conditions, establishes the airplane on a downwind leg at pattern altitude, performs a pre-landing checklist, establishes a speed *below* **Va**, makes the appropriate radio calls, and designates a touchdown point.
    - At the normal abeam point on the downwind, the pilot closes the throttle, applies carb heat as necessary, and establishes a descent at the normal approach airspeed (or 1.3 Vso) +10/-5 knots.
    - Pilot manages the descent and aims for a point so as to make a safe, controlled landing **at or within 400 feet beyond** (within 200 feet for Commercial) **the designated touchdown point**. (The pilot may not touch down before the designated point)
    - Pilot applies wheel and aerodynamic braking techniques.
    - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.
    - Pilot performs a timely go-around if the safe completion of the maneuver *within standards* is in doubt.