VII.F. Normal and Crosswind Approach and Landing

References: Airplane Flying Handbook (FAA-H-8083-3), Procedures during Taxi Operations (AC 91-73), Pilot Wind Shear Guide (AC 00-54), POH/AFM

Objectives

The student should be able to perform a normal approach and landing as prescribed in ACS/PTS. The approach and landing should be performed satisfactorily with or without a crosswind, and with the necessary corrections based on the situation.

Key Elements

1. Stabilized Approach
2. Smooth, Controlled Roundout
3. Hold the airplane inches above the ground before touching down
4. Don't Side Load the Aircraft

Elements

1. Determining Landing Performance and Limitations
2. Downwind Leg
3. Base Leg
4. Final Approach
5. Roundout
6. Touchdown
7. After-Landing Roll
8. Crosswind Approach
9. Go Around
10. Obstructions and Other Hazards to Consider
11. Wind Shear and Wake Turbulence

Schedule

1. Discuss Objectives
2. Review material
3. Development
4. Conclusion

Equipment

1. White board and markers
2. References

IP's Actions

1. Discuss lesson objectives
2. Present Lecture
3. Ask and Answer Questions
4. Assign homework

SP's Actions

1. Participate in discussion
2. Take notes
3. Ask and respond to questions

Completion Standards

The student can fly a coordinated, stabilized approach, transitioning into a smooth roundout and touchdown without side loading the airplane, with or without a crosswind.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The landing is the most difficult, and most fun part of flying. It doesn't matter how good the flight was if the landing was bad.

Overview

Review Objectives and Elements/Key ideas

What

A normal approach and landing involves the use of procedures for what is considered a normal situation; that is, when engine power is available, the wind is light or the final approach is made directly into the wind, the final approach path has no obstacles, and the landing surface is firm and of ample length to gradually bring the airplane to a stop.

Why

It's really a good skill to have when we decide we want to land the plane. Not only that, but the factors involved and procedures used also have applications to the other-than-normal approaches and landings.

How:

1. **Determining Landing Performance and Limitations**
   A. Performance is determined by using the appropriate charts in Chap 5 of the POH
      i. Be competent in using the performance charts in the POH to obtain landing data based on the expected conditions
   B. Limitations are found in Chap 2 of the POH
      i. Limitations applicable to approach and landing can include maximum weights, crosswind limitations, minimum runway length/width, flap/gear extension speeds, stall speeds, center of gravity limitations, etc.
   C. Common Error - Improper use of landing performance data and limitations
2. **Downwind Leg**
   A. Parallel to the runway of intended landing, and normally at 1,000' AGL
      i. Pattern altitude can vary, be aware of local procedures
   B. Checklists
      i. Complete the Before Landing Checklist at the midpoint of the downwind leg
      ii. Common Error - Failure to establish approach and landing configuration at appropriate time or in proper sequence
   C. *Abeam the landing threshold
      i. Begin the descent
         a. Reduce power to 1500 RPM
         b. Extend takeoff flaps
         c. Airspeed - 75 knots
            - Maintain pattern altitude, allowing the airspeed to slow to 75 knots
            - Just before reaching 75 knots, establish the pitch attitude to maintain the airspeed in the descent

D. 45° angle from the runway threshold
    i. At the 45° point begin the turn to base
        a. Shallow to medium bank – recall Rectangular Course procedures to compensate for wind
    ii. At the 45° point the airplane has usually descended approximately 200’ (800’ AGL)
        a. This varies between aircraft

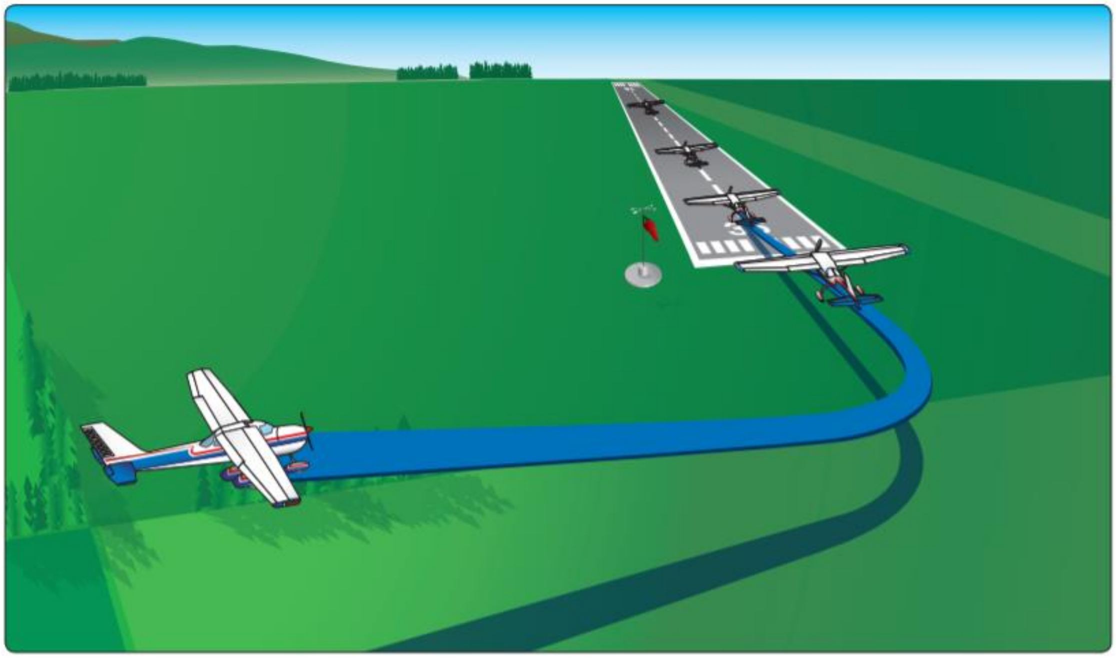
3. Base Leg

A. The leg prior to turning final; perpendicular to the approach end of the runway of intended landing
    i. The base leg is one of the more important judgements made by the pilot in any approach
        a. The pilot must accurately judge the altitude and distance from which a gradual, stabilized descent results in landing at the desired spot
            - The distance of the base leg from the runway depends on the altitude of the base leg, the effect of wind, and the amount of flaps used
                a When there is a strong wind on final, or the flaps are used to produce a steep angle of descent, the base leg must be positioned closer to the runway than would be required with a light wind or no flaps
                b Adjust the turn to the base leg as necessary

B. Configuration
    i. *Airspeed - 70 knots
        a. Adjust pitch and power as necessary to slow from 75 to 70 knots

C. Drift Correction
    i. Maintain a ground track perpendicular to the runway
    ii. It is common for a crosswind to be pushing the airplane away from the runway
        a. This is because landing is made into the wind
        b. Crab into the wind to maintain the course

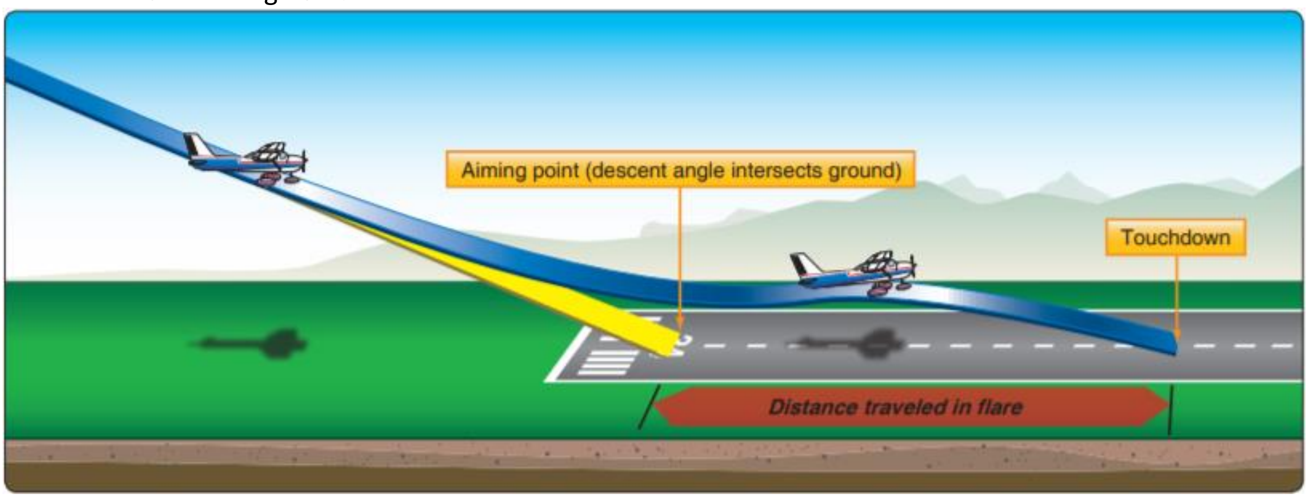
D. The Turn to Final
    i. Medium to shallow bank turn should align the airplane with the centerline of the runway
        a. Recall Rectangular Course and the effects of wind on the bank angle
        b. No more than 30° of bank
            - Stall speed increases rapidly above 30° of bank, this is very unsafe when slow and close to the ground
        c. In the case a steep bank is necessary, a go around is recommended
            - A go around is highly preferred over a steep bank and/or a cross controlled situation
    ii. Usually a descent of approximately 200’ is also made on the base leg (about 600’ AGL to start the turn to final)
        a. This will vary based on aircraft, and conditions (height of the terrain, obstructions along the ground track, flap settings, etc.). Adjust as required
        b. On a 3° glidepath (which is equal to 300’ per nm), 600’ AGL is a two mile descent to the runway



4. **Final Approach**
   A. The longitudinal axis of the airplane is aligned with the center line of the runway and the final descent to the landing runway is made
   B. Configuration
      i. Landing Flaps
      ii. *Airspeed – 65 knots
         a. Adjust pitch and power to establish final approach speed
      iii. *Landing Checklist
   C. A Stable Approach
      i. Common Error - Failure to establish and maintain a stabilized approach
         a. A stabilized approach is a safe approach
         b. An unstable approach increases the risk of excessive rates of descent or slow airspeed while close to the ground
         c. Adjust pitch for airspeed and power for altitude to maintain speed and glidepath
      ii. A stabilized approach is one in which the pilot establishes and maintains a constant angle glidepath towards a predetermined point on the landing runway. It is based on the pilot's judgement of certain visual cues and depends on the maintenance of a constant final descent airspeed and configuration
         a. The objective is to descend at an angle and airspeed that allows the airplane to reach the desired touchdown point at an airspeed that results in minimum floating just before touchdown; in essence, a semi-stalled condition
      iii. Controlling the Descent
         a. Power and pitch are adjusted as necessary to maintain a stabilized approach and glide slope
            - When configured and at final approach speed, the aircraft is below LD_{MAX} and in the Region of Reverse Command
               a Pitch is used to maintain airspeed
               b Power is used to maintain altitude, or glidepath

b. A change in any of the variables requires a coordinated change in the other controllable variables
   - For example, if the pitch attitude is raised too high without an increase in power the airplane settles rapidly and touches down short of the desired spot
     1. For this reason, never try to stretch a glide by applying back-elevator pressure alone to reach the desired landing spot
     2. The gliding distance is shortened if power is not increased simultaneously
   - The proper angle of descent should be maintained by coordinating pitch attitude changes and power changes simultaneously
     a If the approach is too high, reduce power and lower the nose to maintain airspeed
     b If the approach is too low, add power and raise the nose to maintain airspeed
     c Stay on airspeed

iv. The Angle of Descent
   a. Aiming Point



   - The point on the ground at which, if the airplane maintains a constant glidepath, and was not flared for landing, it would strike the ground
     a An airplane descending on final approach at a constant rate and airspeed is traveling in a straight line toward a spot on the ground ahead (the aiming point)
       1. This spot is not the spot on which the airplane will actually touchdown because some float occurs during the round out/flare
   - Select an aiming point in front of the point of intended touchdown
     a *Approximately 400 to 500' in front of touchdown to allow for the airplane's float
       1. This is equal to 2 to 2½ stripes prior to your intended touchdown point
       2. This will vary between aircraft. Select a point appropriate to your airplane's float characteristics
   - Keep the aiming point steady on the wind screen
     a To a pilot moving straight ahead toward an object, the aiming point appears to be stationary in the windscreen, it does not move
       1. Objects in front of and beyond the aiming point do appear to move as the distance is closed

2. If the aiming point begins to move in the windscreen, the descent path has changed and you are no longer aiming at the desired pot. Corrections need to be made

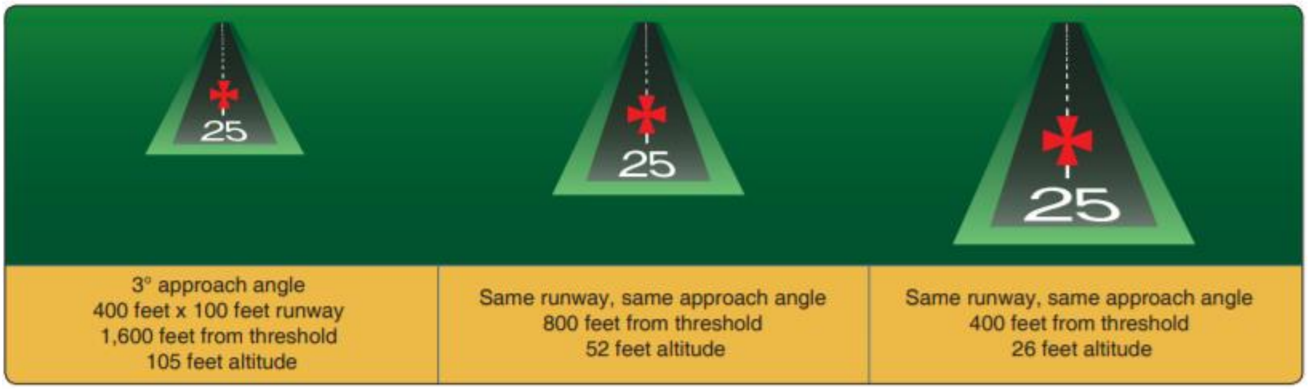
b If the point begins to move up on the windscreen, the airplane is getting too low
   1. Add power and raise the nose to maintain airspeed
      a. The same airspeed with a higher power setting will result in a slower descent, or a climb if enough power is added

c If the point begins to move down on the windscreen, the airplane is getting too high
   1. Reduce power and lower the nose to maintain airspeed
      a. The same airspeed with a lower power setting will result in a steeper descent

d Small, proactive corrections will result in the airplane making a stabilized steady approach to the aiming point on the runway

b. The Runway Image
   - A normal glidepath is 3º (or a 300' per nm descent)
     a Over time, the pilot will learn the site picture for this approach path and can apply the following principles
   - Too High
     a The runway will elongate and become narrower
        1. Overhead view of the runway
   - Too Low
     a The runway will shorten and become wider
        1. Flat view of the runway
   - On Descent Path
     a The runway will be between overhead and flat
     b The runway shape remains the same but grows in size as we approach

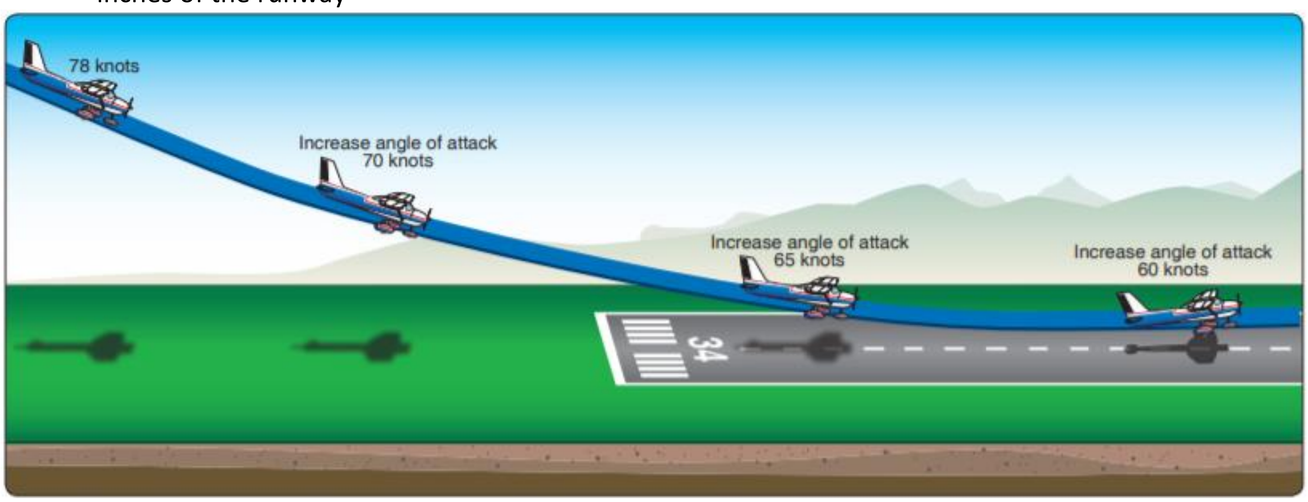
   - The runway should also maintain the same shape as the pilot continues down the approach path
     a When viewed from the cockpit, the runway is seen as a trapezoid with the far end looking narrower than the approach end and the edge lines converging ahead
     b As the pilot continues along the approach, the image the pilot sees is still a trapezoid, but of proportionately larger dimensions (shown below)



D. Common Error - Failure to ensure receipt and acknowledgement of landing clearance
   i. Ensure the controller gave you landing clearance, it was understood, and was read back
      a. The landing clearance needs to be for the specific runway
         - Query and clarify if unsure or unclear about the instructions
         - For example, aligned with 25L but cleared to land 25R
   ii. At the latest, clearance to land should be obtained on final approach (it can come earlier)
   iii. If clearance to land has not been obtained, or there is uncertainty, do not land
      a. Query the controller and/or execute a go around

5. Roundout

A. The roundout is a slow, smooth transition from a normal approach attitude to a landing attitude, gradually rounding out the flight path to one that is parallel with, and within a very few inches of the runway



B. Estimating Height and Movement
   i. Visual focus should not be fixed on any one side or to any one spot ahead
      a. Focus should be changing slowly from a point just over the nose to the desired touchdown zone and back again
      b. Maintain awareness of the distance from either side of the runway with peripheral vision
   ii. Speed and Vision
      a. Speed blurs objects at close range
         - Ex: A car moving at high speed. Nearby objects seem to merge together in a blur, while objects farther away stand out clearly

            - a The driver subconsciously focuses the eyes sufficiently far ahead to see objects distinctly
        - b. The distance at which vision is focused should be proportionate to the speed of the airplane
            - As speed is reduced during the roundout, the distance the pilot focuses ahead of the airplane should be brought closer
        - c. Focusing too close will result in a blurred reference
            - Reactions will be too abrupt or too late
            - Tendencies in this situation include
                - a Overcontrolling
                - b Roundout high
                - c Full stall, drop in landings
        - d. When focused too far, the pilot's ability to judge the closeness of the ground is lost
            - Reactions tend to be slow as there does not seem to be a necessity for action
            - Tendencies in this situation include
                - a Late or little to no flare
                - b Landing nose first
        - e. If focus is gradually changed, being brought progressively closer as speed is reduced, the time interval and the pilot's reaction are reduced and the whole landing process smoothed out
- C. Starting the Roundout
    - i. The roundout is started approximately 10 to 20' above the ground
        - a. Varies between aircraft, and the rate of descent
    - ii. Power is reduced to idle and back elevator is slowly applied gradually increasing the pitch attitude and angle of attack
        - a. Begins putting the nose of the airplane in the desired landing attitude
        - b. Angle of attack is increased at a rate that will allow the airplane to continue settling slowly as airspeed decreases
            - If angle of attack is increased too rapidly, the airplane will climb
- D. Decreasing Lift, Increasing Pitch Attitude
    - i. With the power at idle, airspeed is decreasing. As airspeed decreases, the pilot increases the angle of attack which momentarily increases lift and decreases the rate of descent
    - ii. Airspeed will continue to decrease causing lift to decrease again
        - a. This must be controlled by raising the nose and further increasing the angle of attack
    - iii. Airspeed is being decreased to touchdown speed, while lift is being controlled with back pressure so that the airplane will settle gently onto the runway
- E. Rate of the Roundout
    - i. The rate at which the roundout is executed, depends on the height above the ground, the rate of descent, and the pitch attitude
        - a. High Roundout
            - Executed more slowly to allow the airplane to descend to the ground while the proper landing attitude is being established
        - b. Low Roundout
            - Executed faster to allow the airplane obtain the proper landing attitude before striking the runway surface
        - c. High Rate of Descent

- If the airplane appears to be descending rapidly, the increase in pitch attitude must be made at a correspondingly high rate to arrest the rate of descent and obtain the proper landing attitude before striking the runway surface

d. Low Rate of Descent
- When the airplane appears to be descending very slowly, the increase in pitch attitude must be made at a correspondingly slow rate
- A high rate will likely lead to a rapid loss of airspeed followed by an increased rate of descent to the runway

e. High Pitch Attitude (ex: full flap landing)
- If the airplane is already in a high pitch attitude, the roundout should be executed more slowly to prevent an excessively high pitch attitude

f. Low Pitch Attitude (ex: no flap landing)
- If the airplane is in a low pitch attitude, the roundout should be executed at a faster rate to obtain the proper landing attitude prior to touching down

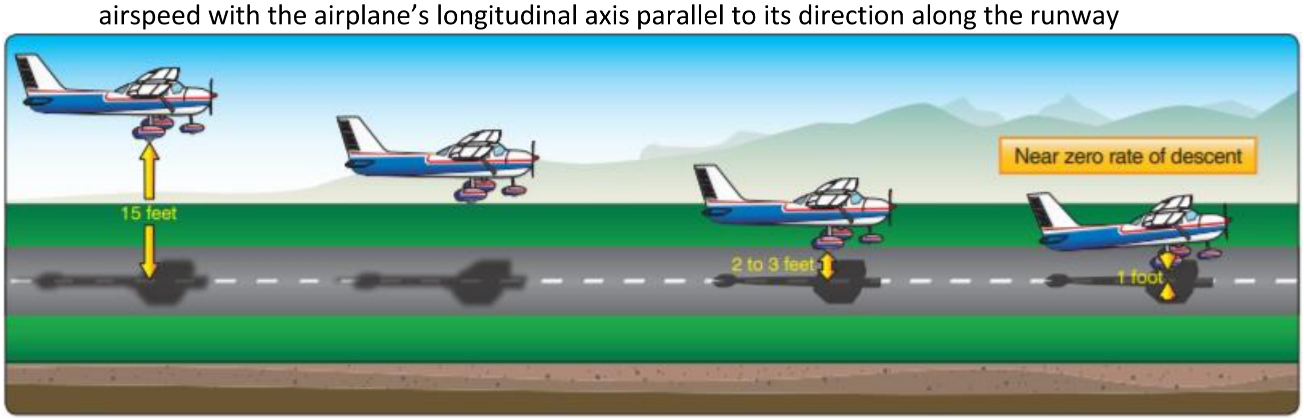
g. Note: Once the roundout has been started, the elevator control should not be pushed forward
- If necessary, relax back pressure or just hold it constant as the airspeed decreases

ii. Common Error - Inappropriate removal of hand from throttles

a. Always be prepared to apply immediate power or initiate a go around

6. Touchdown

A. The gentle settling of the airplane onto the landing surface at the minimum controllable airspeed with the airplane's longitudinal axis parallel to its direction along the runway



B. Ideal Landing

i. Hold the airplane's wheels a few inches off the ground as long as possible with the elevators

ii. In most cases, when the wheels are 2-3' off the ground, the airplane will be settling too fast for a gentle touchdown

a. The descent must be further reduced with further back-elevator pressure

C. Longitudinal Axis

i. The longitudinal axis should be exactly parallel to the direction the airplane is moving along the runway

a. Failure to do this imposes severe side loads on the landing gear

b. Don't land while drifting

c. More below, in the crosswind approach and landing section

D. Rudder Control

i. Less rudder than normal is needed

a. The airplane will fly almost coordinated on its own

b. With the engine at idle, there are little to no left turning tendencies

- The main concern with the rudder during landing is to align the longitudinal axis of the airplane with the runway centerline in the case of a crosswind (more below)

E. After touchdown
  i. Maintain back-elevator pressure
    a. Hold the nosewheel off the ground until the airplane decelerates
      - Maintains a positive angle of attack for aerodynamic braking
  ii. As momentum decreases, gradually relax the back-elevator pressure to allow the nosewheel to gently settle onto the runway
    a. This permits steering with the nosewheel, and better braking action since the entire weight of the airplane is on the wheels (rather than the wings)
    b. This prevents skipping and/or floating after touchdown

F. Common Error - Improper procedure during roundout and touchdown

7. After-Landing Roll

A. The deceleration of the airplane to the normal taxi speed, or when the airplane has been brought to a complete stop when clear of the landing area

B. Directional Control on the Ground
  i. Rudder
    a. The rudder serves the same purpose on the ground as it does in the air – the yaw of the airplane
      - With the nosewheel on the ground, use the rudder to steer the airplane on the ground
      - Rudder effectiveness is dependent on airflow which is dependent on the speed of the plane
        a As speed decreases throughout the landing roll, the steerable nose provides more positive directional control
    b. The airplane will tend to weathervane (or point) into the wind
      - With the main wheels acting as a pivot point, and a greater surface area exposed to the crosswind behind that pivot point, the airplane tends to point, or weathervane, into the wind
      - Use rudder to maintain directional control
  ii. Aileron Control
    a. Like rudders, the ailerons serve the same purpose on the ground as they do in the air – they change the lift and drag components of the wings
      - During the after-landing roll they are used to keep the wings level
    b. As airspeed decreases during the landing roll the ailerons become less effective, therefore increasing aileron must be applied into a crosswind to keep the upwind wing from rising
  iii. Be alert throughout the landing roll
    a. Be alert for directional control difficulties immediately upon and after touchdown due to the ground friction on the wheels
      - Loss of Directional Control
        a May lead to an aggravated, uncontrolled, tight turn on the ground (ground loop)
          1. Combination of centrifugal force acting on the center of gravity and ground friction of the main wheels resisting it during the ground loop may cause the airplane to tip or lean enough for the outside wingtip to contact the ground
          2. This could impose a sideward force that could collapse the landing gear
    b. Remain vigilant throughout the landing roll and keep positive control of the airplane

- Accidents occur when pilots abandon vigilance and positive control
- Don't assume that because the airplane is on the ground your work is done

iv. Common Error - Poor directional control after touchdown

C. Braking

i. The brakes serve the same primary purpose as the brakes on a car – to reduce speed while on the ground

a. In airplanes, they are also used to aid in directional control when the rudder is insufficient
   - Brake pressure can be applied in the direction of a turn to assist the rudder

ii. Using the Brakes

a. On an airplane equipped with toe brakes (most airplanes), the pilot slides the toes or feet up from the rudder pedals to the brake pedals
   - If rudder pressure is being held at the same time braking is needed, do not release the rudder pressure

b. Brake pressure is applied by pushing forward on the toe pedals

c. During the ground roll, the airplane's direction of movement can be changed by carefully applying pressure on one brake or uneven pressure on each brake in the desired direction
   - Caution must be exercised when applying brakes to avoid overcontrolling, especially at high speeds

iii. Effective Braking

a. Put maximum weight on the main wheels after touchdown
   - The nosewheel should be lowered to the runway to maintain directional control
   - After the nose is down, back pressure is applied to the controls without lifting the nosewheel off the ground
     - a This enables directional control while keeping weight on the main wheels
     - b If the pilot were to brake without holding back pressure, the nose tends to pitch down which transfers weight from the main wheels to the nosewheel
       1. This does not help braking. Maximum weight should be on the main wheels to improve brake performance

b. Gently and evenly apply the brakes
   - Maximum brake effectiveness is just short of the point where skidding occurs
     - a Maximum braking is not necessary in most landings
     - b If the brakes are applied so hard that skidding takes place, braking becomes ineffective
       1. To stop skidding, release the brake pressure and reapply the brakes with less force
   - Brake effectiveness is not enhanced by applying, releasing, and reapply brake pressure (pumping the brakes)
     - a Apply the brakes firmly and smoothly

iv. Common Error - Improper use of brakes

a. Ensure feet are not on the brakes at touchdown, this could result in lost control and blown tires

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

i. Have a plan of where you plan to exit the runway and how to taxi to your destination

a. Make adjustments as necessary if unable to exit as planned

        ii. Review and be familiar with potential hot spots (be extra cautious for traffic at these spots)
        iii. Listen to, and ensure understanding of the controller's instructions
            a. Vital to avoiding incursions
            b. Query the controller if unsure of the instructions
    E. After Landing Checklist
        i. Perform once safely clear of the runway

8. Crosswind Approach

    A. A landing which must be made while the wind is blowing across rather than parallel to the landing direction
    B. The same basic principles apply to a crosswind approach and landing as a normal approach and landing
    C. Two methods of accomplishing a crosswind approach and landing
        i. Crab Method

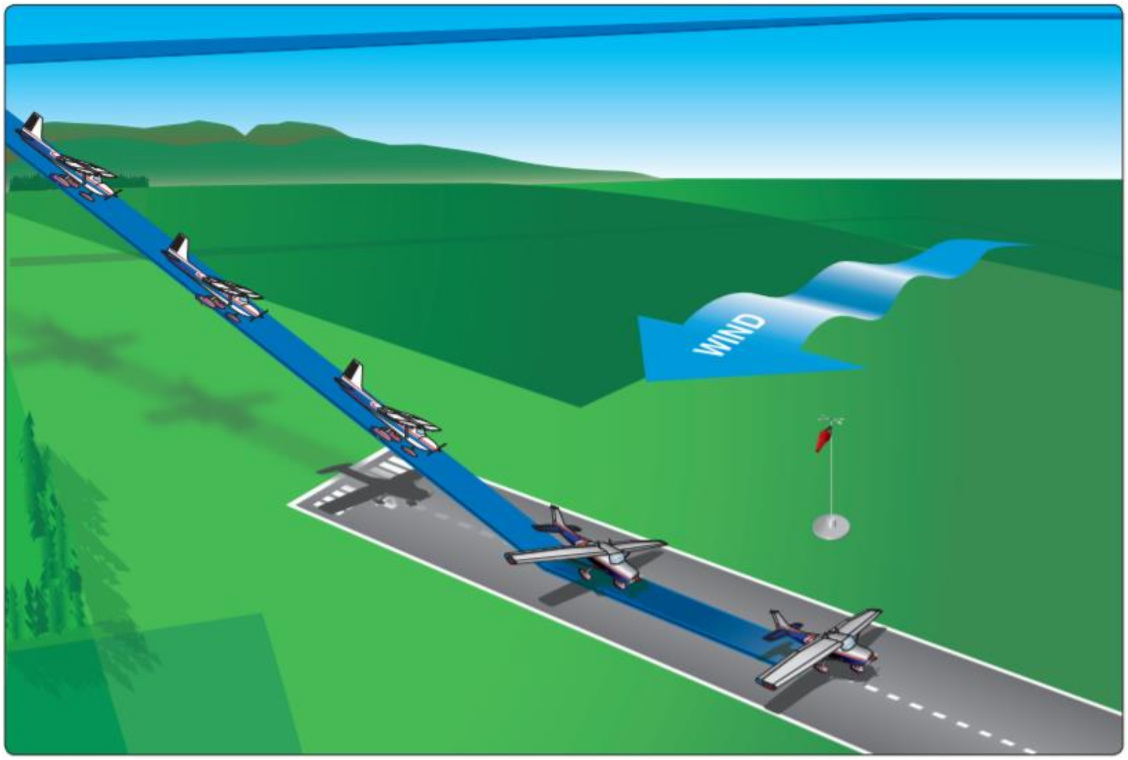
            a. Easier to maintain during final approach, but requires a high degree of judgment and timing in removing the crab right before touchdown
            b. How it Works
                • The pilot establishes a crab into the wind so that the airplane's ground track remains aligned with the centerline of the runway
                • The crab is maintained until just prior to touchdown, when the longitudinal axis of airplane is aligned with the runway to avoid a sideward touchdown of the wheels/airplane
            c. Not recommended
        ii. Sideslip (wing-low) Method (shown to the right)
            a. Recommended method

    D. Final Approach
        i. Sideslip (Wing-Low)
            a. Align the airplane's heading with the centerline of the runway, noting the rate and direction of drift
            b. Promptly apply drift correction
                • Lower the upwind wing
                    a Amount of lowering depends on the drift
            c. When the wing is lowered, the airplane tends to turn in that direction
                • To compensate for the turn, simultaneous opposite rudder pressure is necessary to keep the longitudinal axis of the airplane aligned with the runway
                • The airplane will be side-slipping into the wind just enough so that the flight path and ground track are aligned with the runway
            d. Changes in the crosswind are corrected for accordingly
                • Drift is controlled with aileron, and heading with rudder
                    a Use ailerons to keep the airplane over the extended runway centerline
                    b Use rudder to keep the longitudinal axis aligned with the runway centerline
            e. Strong Crosswind
                • To correct for a strong crosswind, the slip is increased by lowering the wing into the wind

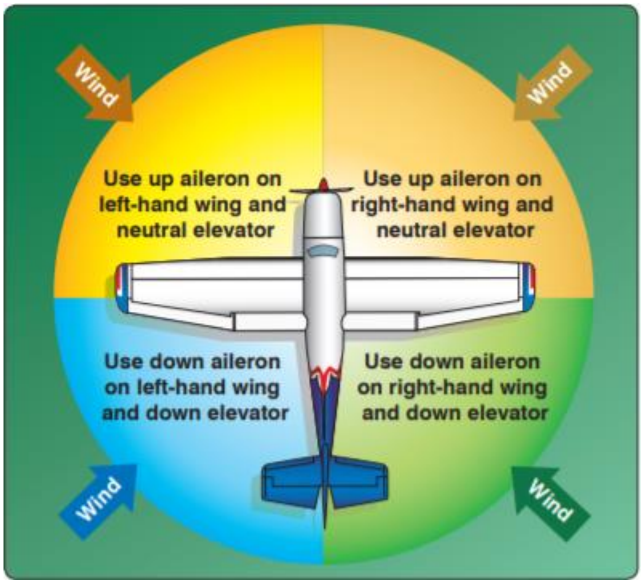
            a To compensate for the additional bank, additional rudder is applied to keep the longitudinal axis of the airplane aligned with the runway centerline
            b At some point, there will not be insufficient rudder available to overcome the turning tendency caused by the steepened bank
                1. If the bank required is such that full opposite rudder does not prevent a turn, the wind is too strong to safely land the airplane on that runway, in those conditions, the pilot should find a more suitable runway
                2. At this point the wind has exceeded the airplane's crosswind performance capabilities
                    a. Always be aware of the airplane's crosswind limitations
    f. Maintain a stabilized approach
        - Same as a normal approach, except with the added sideslip
        - Because you are in a slip, drag is increased and more power will be necessary to maintain a given descent rate
            a Pitch for airspeed
            b Adjust power for altitude

ii. Roundout
    a. Generally made like a normal landing approach, but the crosswind correction is maintained/continued as necessary to prevent drifting
        - Don't level the wings. Keep the upwind wing down throughout the roundout
            a Leveling the wings will result in drifting, which will side loading the gear
    b. Gradually increase the deflection of the ailerons and rudder to maintain drift correction as the airplane slows
        - The controls become less effective as airspeed is decreased

iii. Touchdown
    a. The touchdown should be made on the upwind main wheel first
        - Continue to maintain the crosswind corrections to prevent drift
        - During gusty or high wind conditions, prompt adjustments must be made in the crosswind corrections to assure the airplane does not drift as it touches down
    b. As the momentum decreases, the weight of the airplane will cause the downwind main wheel to gradually settle onto the runway, then the nosewheel
        - If your airplane has nose-wheel steering interconnected with the rudder, the nosewheel will not be aligned with the runway because opposite rudder is being held for the crosswind correction
            a To prevent swerving, the corrective rudder pressure must be promptly relaxed as the nose wheel touches down



iv. After Landing Roll
   a. Special attention must be given to maintaining directional control by the use of rudder or nose-wheel steering, while keeping the upwind wing from rising by use of aileron
   b. Maintain directional control with rudders
      - With the main wheels acting as a pivot point, and a greater surface area exposed to the crosswind behind that pivot point, the airplane tends to point or weathervane into the wind
   c. Maintain crosswind control with ailerons
      - As the airplane decelerates, more and more aileron is applied to keep the upwind wing from rising
         a Since the airplane is slowing down, there is less airflow around the ailerons and they become less effective
      - When the airplane is coming to a stop, aileron control should be held fully into the wind



9. Go Around
   A. Used whenever landing conditions are not satisfactory
      i. A go around can be executed for numerous reasons, but for this lesson we'll focus on an unstable approach

a. If the pilot cannot establish and maintain a stable approach, go around and set up again

B. Go around anytime safety is compromised or the touchdown point is going to be missed

C. Go Around Flow
  i. Full power
  ii. Landing flaps are retracted
  iii. Climb out at V_Y (or V_X, if required)
    a. Upon reaching V_Y (or V_X), and at a safe altitude, takeoff flaps can be retracted

D. For more information, see VII.H. Go-Around/Rejected Landing

10. Obstructions and Other Hazards to Consider

A. Strong/Gusty Winds
  i. Increase speed on final approach
    a. *Approach speed (65 knots) + ½ the gust factor
      - EX: Wind at 12 knots gusting to 20 (8 knot gust factor)
        a Approach at 65 knots + 4 knots = 69 knots
    b. Use flaps as recommended in the POH

B. Obstacles
  i. Trees, Towers, Construction equipment
  ii. Be aware of any obstructions in the pattern/on the approach and/or takeoff path
    a. Ensure the airplane performance can handle the obstructions

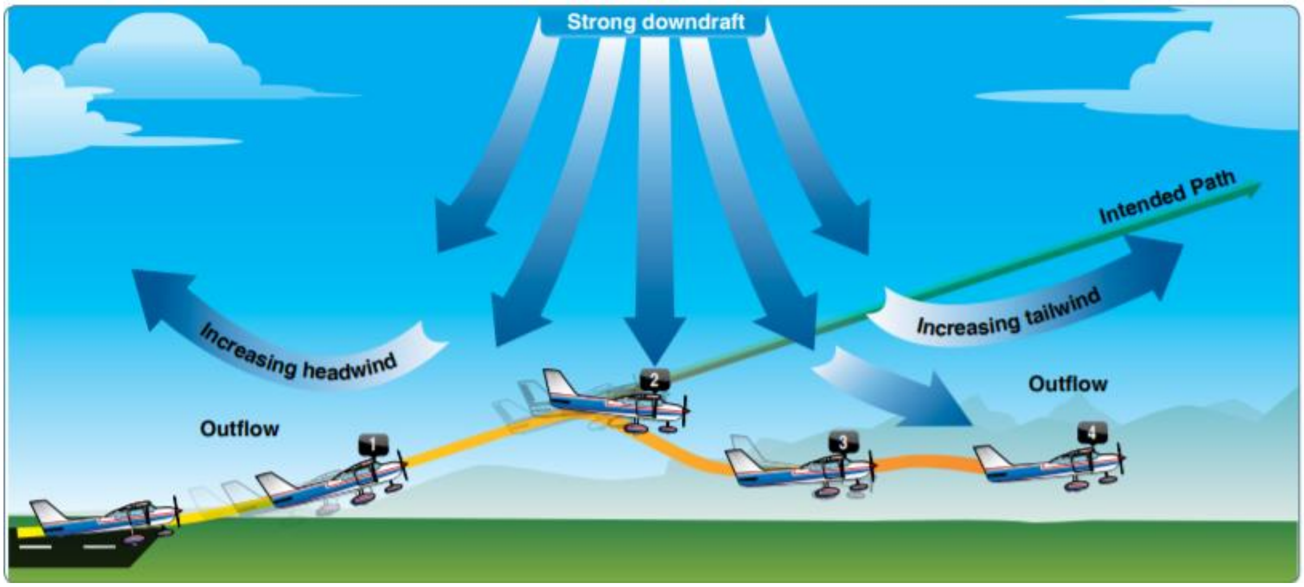
C. Traffic
  i. Always be aware of, and looking for, other traffic
    a. Build a mental picture not only of the traffic you can see, but also the traffic that is reported whether by ATC, or other radio calls

11. Wind Shear and Wake Turbulence

A. Wind Shear
  i. What is it?
    a. A sudden, drastic change in wind speed and/or direction over a very small area
    b. While wind shear can occur at any altitude, low-level wind shear is especially hazardous due to the proximity to the ground
      - Low-level wind shear is commonly associated with passing frontal systems, thunderstorms, temperature inversions, and strong upper level winds (greater than 25 knots)
  ii. Why is it dangerous?
    a. Wind shear can subject an aircraft to violent updrafts and downdrafts, as well as abrupt changes to the horizontal movement of the aircraft
    b. It can rapidly change the performance of the aircraft and disrupt the normal flight attitude, for example:
      - A tailwind can quickly change to a headwind causing an increase in airspeed and performance
      - A headwind can quickly change to a tailwind causing a decrease in airspeed and performance
    c. Microbursts
      - The most severe type of wind shear
        a Associated with convective precipitation into dry air at cloud base
      - Typical Microburst
        a Horizontal diameter of 1-2 miles
        b Depth of 1,000’

- c Lifespan of 5-15 minutes
- d Downdrafts of up to 6,000 feet per minute
- e Headwind losses of 30-90 knots (seriously degraded performance)
- f Strong turbulence and hazardous wind direction changes

- Flying through a Microburst
  - a During an inadvertent takeoff into a microburst, the plane may first experience a performance-increasing headwind (1)
  - b Followed by performance-decreasing downdrafts (2)
  - c Followed by a rapidly increasing tailwind (3)
    1. This can result in terrain impact or flight dangerously close to the ground (4)
  - d An encounter during approach involves the same sequence of wind changes and could force the plane to the ground short of the runway



- Indications
  - a Visual
    1. Intense rain shaft at the surface, but virga at cloud base
    2. Ring of blowing dust
  - b Alerting Systems
    1. The FAA has invested in substantial microburst accident prevention
    2. LLWAS-NE, TDWR, and ASR-9 WSP systems installed at major airports
       a. Very few false alerts, and detect microbursts well above 90% detection rate requirement established by congress
    3. Many airports, especially smaller airports, have no wind shear systems
       a. AC 00-54 – FAA Pilot Wind Shear Guide
          i. Includes information on how to recognize the risk of a microburst encounter, how to avoid an encounter, and the best strategy for escape
          ii. Tailored to jet aircraft, but still very useful information

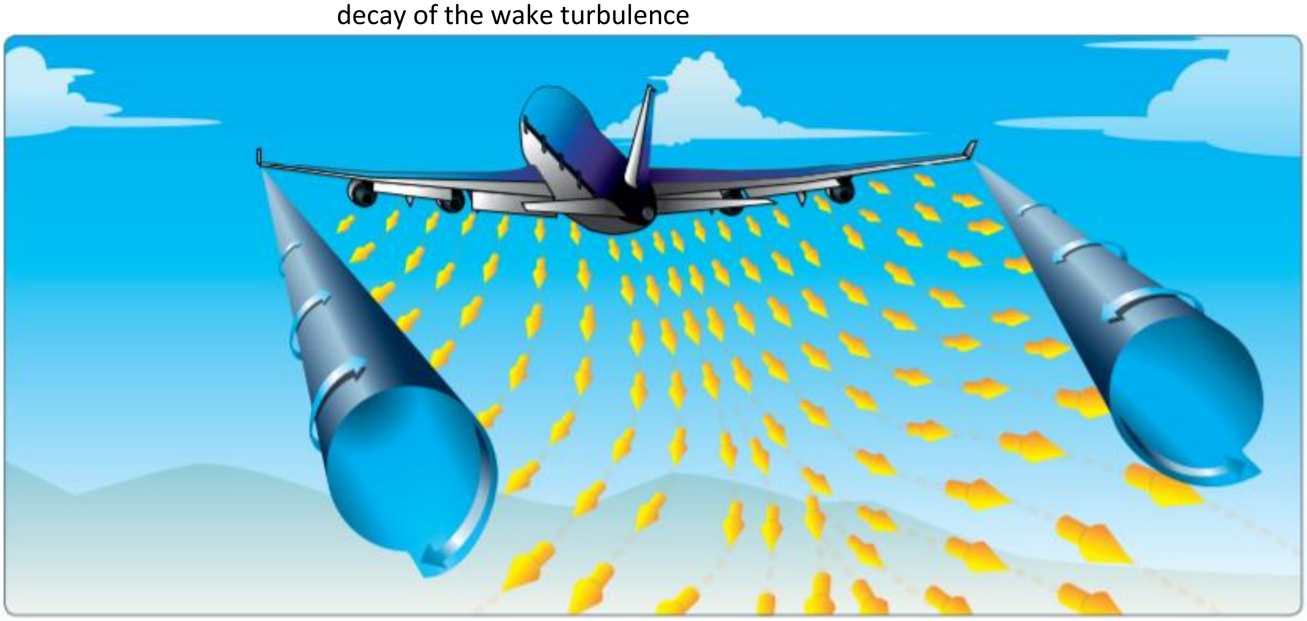
iii. Handling Wind Shear
  a. If at all possible, avoid it
    - Never conduct traffic pattern operations in close proximity to an active thunderstorm

a Be alert for visual cues and any alerting systems
b Do not takeoff if wind shear is in the area
- LLWAS (Low Level Wind Shear Alerting System)
  a If available can warn of impending wind shear
- PIREPS
  a Can be very informational/helpful if a pilot has reported wind shear in the area

b. Approach into Wind Shear
- Follow the POH procedures. If none, general wind shear techniques include:
  a Higher power and a faster airspeed during approach
    1. Add ½ the gust factor to the approach speed
  b Stay as high as feasible until necessary to descend
    1. Altitude is your friend
  c Go around at the first sign of an unexpected pitch or airspeed change
    1. Important to get FULL power and get the airplane climbing
    2. If the aircraft is descending toward the ground, ensure max power, and increase the pitch attitude as far as possible without stalling the airplane
       a. The intent should be to keep the airplane flying as long as possible in hope of exiting the shear

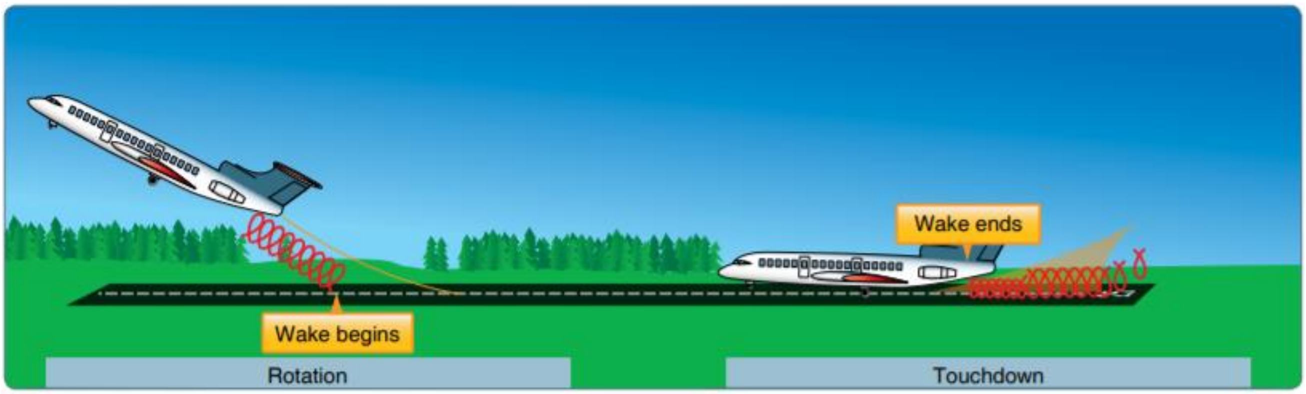
B. Wake Turbulence
i. What is it?
a. Wake turbulence, or wingtip vortices, are the byproduct of lift
- The difference between the high pressure below the wing and low pressure above the wing causes the air move outward, upward and around the wingtips, leading to two counter rotating cylindrical vortices extending off the wingtips

b. All aircraft generate wake turbulence during flight
- Generally, the larger the aircraft, the stronger the vortices
- Strength can vary
  a Vortices are strongest when the pressure differential is the greatest, or when the aircraft is heavy, clean, and/or slow
    1. The turbulence from a “dirty” aircraft configuration actually accelerates the decay of the wake turbulence



i. Why is it dangerous?
   a. The rolling moments caused by the wake turbulence of a larger aircraft can be so strong that it exceeds the airplanes control authority
      - The rolling moments can be violent, and potentially unrecoverable
   b. If encountered at a close range, the turbulence generated by these vortices can damage aircraft components and equipment
   c. Wake turbulence can be encountered in any phase of flight
      - Although usually strongest during departure, aircraft generate vortices during cruise flight and on approach

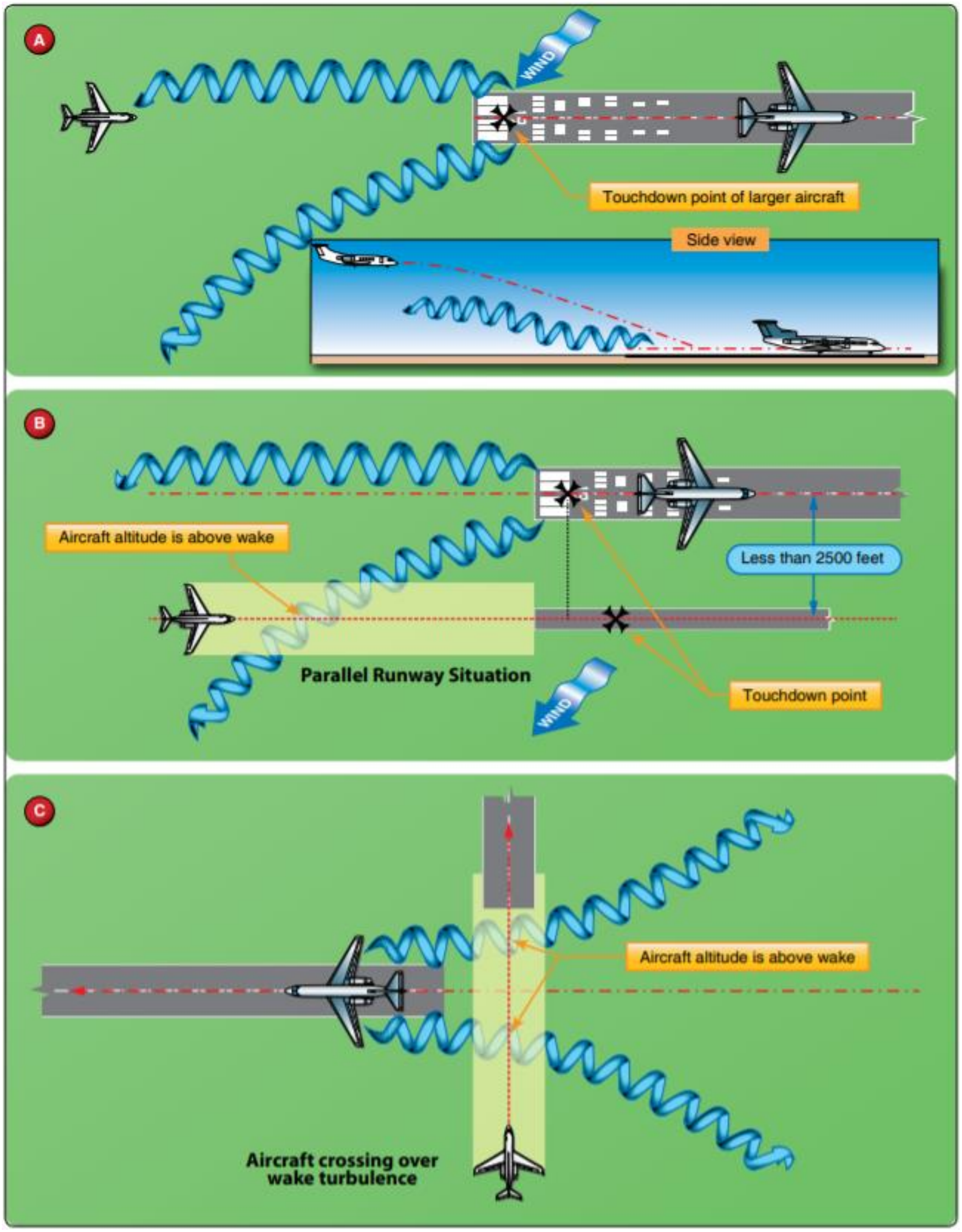
ii. Vortex Behavior



   a. Vortices are generated from the moment an aircraft leaves the ground, until it touches down
   b. Vortices tend to remain spaced a bit less than a wingspan apart, drifting with the wind, at altitudes greater than a wingspan above the ground
   c. Vortices tend to sink at a rate of several hundred feet per minute, slowing their descent and diminishing in strength over time
      - When the vortices of large aircraft sink close to the ground (100-200'), they tend to move laterally over the ground at a speed of 2-3 knots
         a A crosswind decreases the lateral movement of the upwind vortex and increases the movement of the downwind vortex
         b A light quartering tailwind produces the worst scenario in which the wake vortices could be present along a significant portion of the final approach and extended centerline and not just in the touchdown zone as typically expected

iii. Avoidance Procedures
   a. Maintain adequate separation
   b. Approach
      - When behind a larger aircraft on the same runway— stay at or above the larger aircraft's approach flight path and land beyond its touchdown point
      - When behind a larger aircraft on a parallel runway closer than 2,500 feet—consider the possibility of drift and stay at or above the larger aircraft's final approach flight path and note its touchdown point (Figure B)
   c. Landing
      - When landing behind a departing aircraft on the same runway—land prior to the departing aircraft's rotating point
         a Land beyond an arriving jet's touchdown point
      - When landing behind a larger aircraft on a crossing runway— cross above the larger aircraft's flight path (Figure A)

- When landing behind a larger aircraft on a crossing runway—note the aircraft's rotation point and, if that point is past the intersection, continue and land prior to the intersection (Figure C)
  - a If the larger aircraft rotates prior to the intersection, avoid flight below its flight path Abandon the approach unless a landing is ensured well before reaching the intersection
- When landing after a large aircraft executing a low approach, missed approach, or touch-and-go landing, it is prudent to wait at least 2 minutes prior to a takeoff or landing
  - a This is because vortices settle and move laterally near the ground, the vortex hazard may exist along the runway and in the flight path, particularly in a quartering tailwind



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 throttles
- Improper procedure during roundout and touchdown
- Poor directional control after touchdown

- Improper use of brakes
- 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

Conclusion:
Brief review of the main points
As simple and basic a procedure as this seems to be, a lot goes into a well-executed approach. Putting all of these parts together over time will result in a much more confident, safe, and skilled pilot. The fine nuances of a stabilized, well planned approach are well worth the end result the first time you 'grease' a landing.

PTS Requirements:
To determine that the applicant:

1. Exhibits instructional knowledge of the elements of a normal and a crosswind approach and landing by describing:
    a. How to determine landing performance and limitations.
    b. Configuration, power, and trim.
    c. Obstructions and other hazards which should be considered.
    d. A stabilized approach at the recommended airspeed to the selected touchdown area.
    e. Course of action if selected touchdown area is going to be missed.
    f. Coordination of flight controls.
    g. A precise ground track.
    h. Wind shear and wake turbulence avoidance procedures.
    i. Most suitable crosswind procedure.
    j. Timing, judgment, and control procedure during roundout and touchdown.
    k. Directional control after touchdown.
    l. Use of brakes (landplane).
    m. Use of checklist.
    n. After landing runway incursion procedures.
2. Exhibits instructional knowledge of common errors related to a normal and a crosswind approach and landing by describing:
    a. Improper use of landing performance data and limitations.
    b. Failure to establish approach and landing configuration at appropriate time or in proper sequence.
    c. Failure to establish and maintain a stabilized approach.
    d. Inappropriate removal of hand from throttles.
    e. Improper procedure during roundout and touchdown.
    f. Poor directional control after touchdown.
    g. Improper use of brakes (ASEL).
    h. Failure to ensure receipt and acknowledgement of landing clearance.
    i. Failure to review airport diagram for runway exit situational awareness to avoid a runway incursion after landing.
3. Demonstrates and simultaneously explains a normal or a crosswind approach and landing from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to a normal or crosswind approach and landing.

Private Pilot ACS Skills Standards

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Ensure the aircraft is aligned with the correct/assigned runway or landing surface.
4. Scan the landing surface and adjoining area for traffic and obstructions.
5. Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
6. Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
7. Maintain manufacturer’s recommended approach airspeed, or in its absence, not more than 1.3 V_{SO}, +10/-5 knots with gust factor applied.
8. Maintain directional control and appropriate crosswind correction throughout the approach and landing.
9. Make smooth, timely, and correct control application during round out and touchdown.
10. Touch down at a proper pitch attitude, within 400 feet beyond or on the specified point, with no side drift, and with the aircraft’s longitudinal axis aligned with and over the runway center/landing path.
11. Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
12. Utilize runway incursion avoidance procedures.

Commercial Pilot ACS Standards

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Ensure the aircraft is aligned with the correct/assigned runway or landing surface.
4. Scan the landing surface and adjoining area for traffic and obstructions.
5. Select and aim for a suitable touchdown point considering the wind, landing surface, and obstructions.
6. Establish the recommended approach and landing configuration and airspeed, and adjust pitch attitude and power as required to maintain a stabilized approach.
7. Maintain manufacturer’s recommended approach airspeed, or in its absence, not more than 1.3 V_{SO}, ± 5 knots with gust factor applied.
8. Maintain directional control and appropriate crosswind correction throughout the approach and landing.
9. Make smooth, timely, and correct control application during round out and touchdown.
10. Touch down at a proper pitch attitude, within 200 feet beyond or on the specified point, with no side drift, and with the aircraft’s longitudinal axis aligned with and over the runway center/landing path.
11. Execute a timely go-around if the approach cannot be made within the tolerances specified above or for any other condition that may result in an unsafe approach or landing.
12. Utilize runway incursion avoidance procedures.