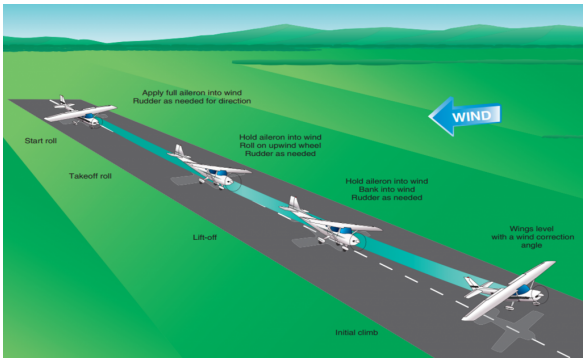
Normal and Crosswind Takeoff and Climb

Objective	
To ensure the applicant learns the purpose of and can exhibit a clear understanding of normal takeoff and climb maneuver and how to perform the maneuver properly.	
Purpose	
Every flight begins with a takeoff. Getting up into the air can appear easy, but doing it safely requires pilots to develop better control of the airplane to manage varying wind conditions and airplane climb performance.	

Schedule	**Equipment**

• **Ground Lesson**: 15 minutes
• Initial
  ▪ **Flight**: 10 minutes - *Introduction to Maneuver*
  ▪ **Flight**: 20 minutes (per flight) - *Practice*
• Solo
  ▪ **Flight**: 20 minutes (per solo flight) - *Improve Proficiency*
• Pre-Checkride
  ▪ **Flight**: 10 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, sideslips, crosswind technique, Vx and Vy.
- **Flight**: Student can perform the maneuver to the applicable ACS standards.
  - Configures airplane for takeoff, performs pre-takeoff checklist, and verifies takeoff runway.
  - Makes appropriate crosswind corrections and rotates at Vr.
  - Pitches for and maintains a climb at Vy (+10/-5 knots Private Pilot, +/-5 knots Commercial).
  - See expanded Completion Standards below.

References

- ERAUSpecialVFR - “Normal and Crosswind Takeoff and Climb”
  - YouTube - https://www.youtube.com/watch?v=l5ZxnVu-A1E
- FAA-H-8083-3B (Airplane Flying Handbook) - Chapter 5, Page 2-3 [Prior to Takeoff], Chapter 5, Page 3-6 [Normal Takeoff], Chapter 5, Page 6-9 [Crosswind Takeoff], Chapter 5, Page 12-13 [Rejected Takeoff/Engine Failure]
- FAA-H-8083-25B (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 5, Page 9-10 [Avoiding Wake Turbulence], Chapter 5, Page 30-33 [Left Turning Tendencies], Chapter 11, Page 12-15 [Takeoff Performance], Chapter 11, Page 19-28 [Performance Charts]
- FAA-S-ACS-6B (Private Pilot ACS) - Area IV Task A
- FAA-S-ACS-7A (Commercial Pilot ACS) - Area IV Task A
- FAA-S-8081-6D (CFI PTS) - Area VII Task A

Ground Lesson Outline

- Takeoffs
- Airplanes Fly With The Air
  - Crosswinds, crabbing
- Sideslips
- Crosswind Technique
- Runway Safety
- Best Angle of Climb and Best Rate of Climb
- Left-Turning Tendencies
- Takeoff Performance
  - Density altitude
- Safety considerations
  - Use of checklists
  - Visual traffic scanning
  - Runway incursion avoidance
  - Be prepared to go around
- Maneuver Description - step-by-step
  - Entry position, airspeed, etc.
- Expanded Completion Standards

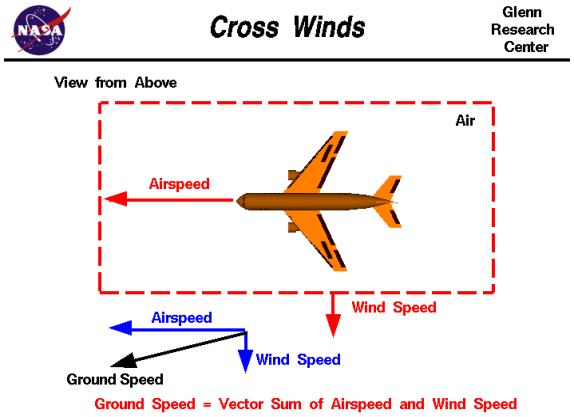
Common Errors

- Improper runway incursion avoidance procedures.
- **Improper use of controls during a normal or crosswind takeoff.**
- **Inappropriate lift-off procedures.**
- Improper climb attitude, power setting, and airspeed (VY).
- Improper use of checklist

Ground Lesson Content

- **Takeoffs** - All flights begin with a takeoff. Compared to landings, takeoffs are generally a simple maneuver, and many student pilots are able to perform them on the first lesson. However, proper, safe crosswind takeoff technique is an essential piloting skill. Pilots must be aware of the aerodynamics of slips, the performance and limitations of their aircraft, and how to manage the subsequent climb.
- **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. The same is true of takeoffs.

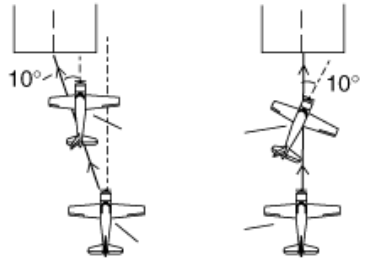
  - Although airplanes generally fly straight courses through the air, when the movement of the air is added, these courses are different across the ground. **The *ground track* of an airplane is the combination of it's *airspeed (speed through the air)*, *heading (the direction it is pointing)*, and the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



  - **Almost all takeoffs are *crosswind* takeoffs.** 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.
  - An airplane which is tracking a course along the ground by aligning its nose with another direction is said to be *crabbing.*
  - In order to safely take off on runways, which are never moving, in winds, which are always moving, airplanes need to apply a correction to track the runway in a straight line. Airplane landing gear are just wheels, and just like a car or any other vehicle, they need to point in the

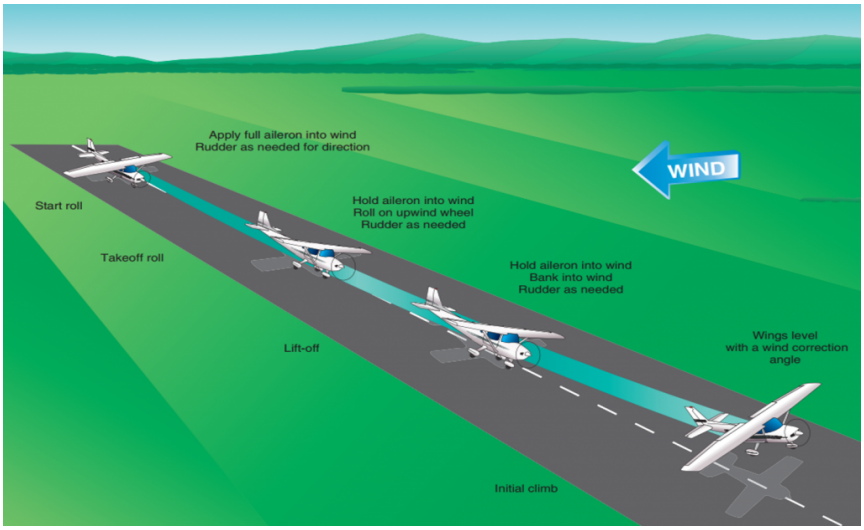
direction of travel. **So as an airplane makes its takeoff roll, its wheels need to stay aligned with the runway.**

- **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*.
    - As an airplane accelerates to takeoff speed, it 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 traveling 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.

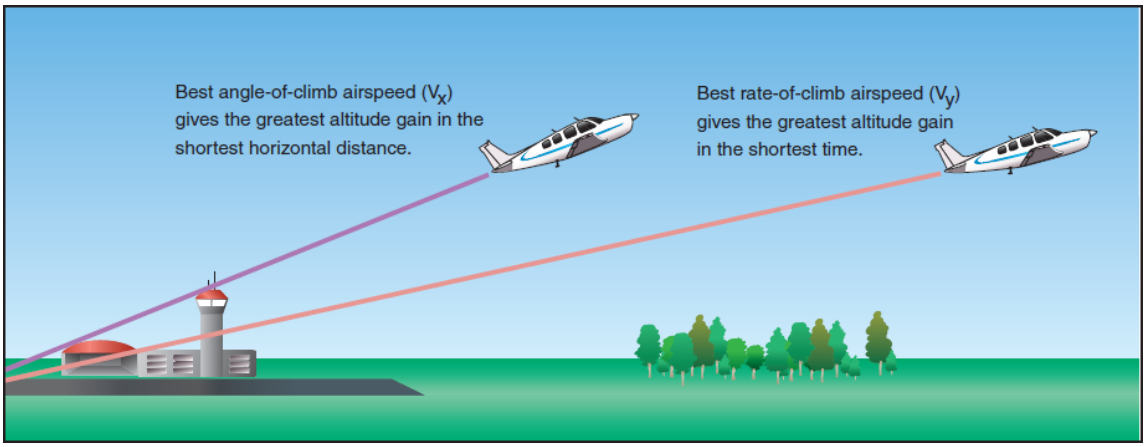
- **Crosswind Technique** - Pilots can use their knowledge of sideslips to take off in crosswinds:
    - As the airplane aligns with the runway for takeoff, the pilot begins by 'crossing the controls', with the aileron *into the direction of the wind*, which, once the airplane has accelerated enough to make the controls aerodynamically effective, puts the plane into a sideslip and keeps the airplane aligned with 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)**, and the airplane will leave the ground downwind wheel first, and then upwind wheel**.**



- **As the airplane leaves the ground, the crosswind correction can be relaxed and the airplane will naturally *weathervane***, which is to say it aligns itself towards the wind, and flies in a *crabbed* orientation.

- **Runway Safety** - All takeoffs generally start with the airplane crossing over a *hold short* line, which is the line that indicates where the runway area begins. Hold short lines should be taken very seriously!
  - Before crossing a hold short line:
    - At a towered airport, the pilot must have received a taxi, runway crossing, or takeoff clearance for the runway they are about to enter.
    - At a non-towered airport, the pilot has communicated their intentions over the radio (Common Traffic Advisory Frequency--CTAF), and has visually verified that there is no traffic on final approach for the runway, or on the runway itself, which would conflict.
- **Best Angle of Climb and Best Rate of Climb** - When performing a takeoff and climb, there are two important speeds that pilots must memorize for their aircraft:
  - **Vx** - The best *angle* of climb.
  - **Vy** - The best *rate* of climb.
- Climbing at the best *angle* of climb means that the airplane will climb more steeply away from the ground, and is usually used for avoiding obstacles which may be present especially near small runways.

- Climbing at the best *rate* of climb is more commonly used, and it means the airplane will climb faster, but at a shallower angle. This is used to gain the most altitude in the shortest amount of time. This is normally the speed pilots will use after most takeoffs.



- **Left-Turning Tendencies** - This maneuver illustrates the strong effects of left-turning tendencies at low airspeeds and high angle of attack. Because full power is applied while the airplane is at low speed, before the airplane has reached flying speed, the rudder has limited effectiveness and **significant right rudder pressure may be required to maintain runway centerline**. Likewise, after takeoff and while initially climbing, the airplane will be flying at a high angle of attack and high power setting, exaggerating the torque reaction, spiraling slipstream, and P-Factor, again requiring significant right rudder pressure.

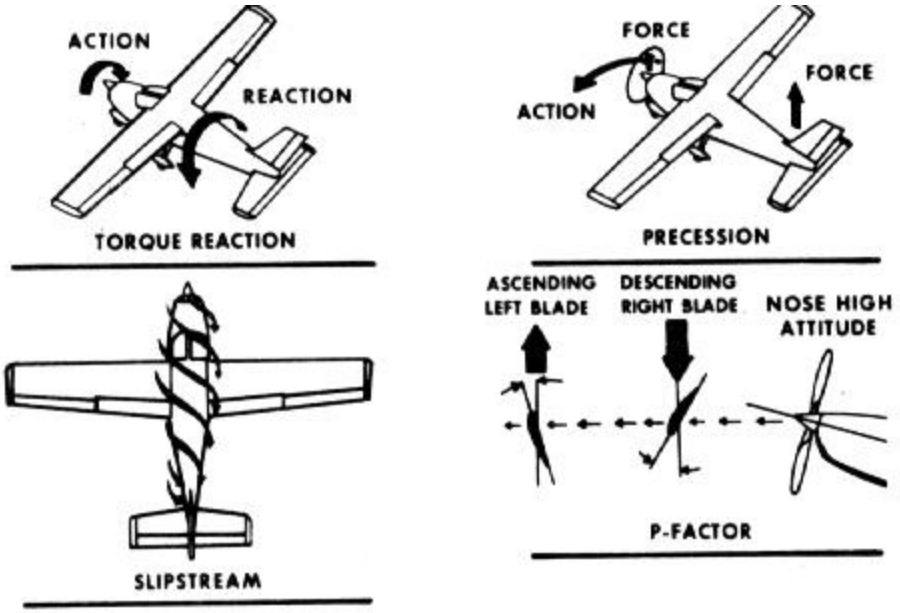


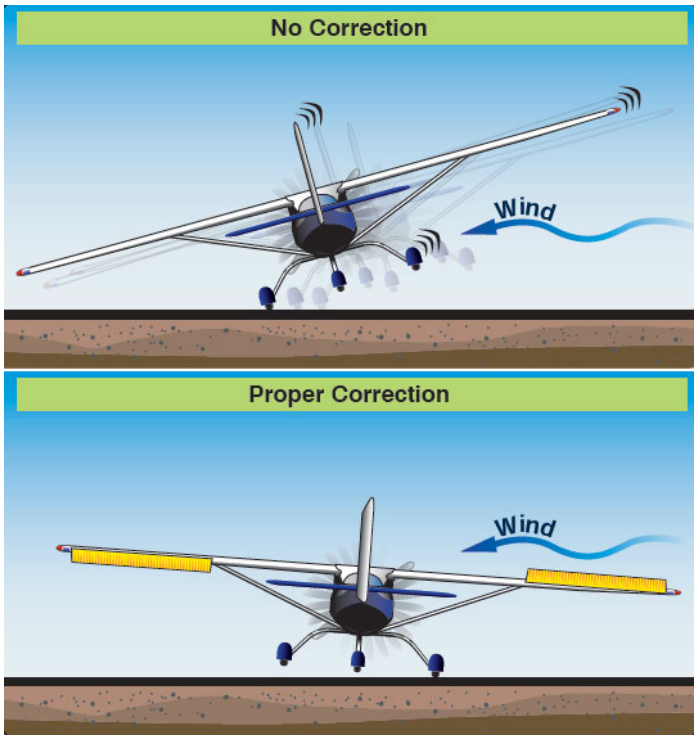
Figure 3–6 Left Turning Tendencies

- **Takeoff Performance** - Determining exactly how much distance will be required for takeoff is crucial to ensure the chosen runway will be long enough to depart safely. An airplane's takeoff 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 takeoff distance is required for various weights, winds, and weather conditions. It also prescribes an airplane configuration that should be used.
- **Safety Considerations**
    - As with any takeoff, the **use of checklists is important**. Before entering the runway area, the before takeoff checklist must be completed.
    - **All takeoffs require caution to be exercised for obstacles on or near the field!** Powerlines, tall trees, or other obstacles may be quite close to the runway environment! These obstacles may be difficult to see in a nose-high attitude after takeoff, so a thorough takeoff briefing which highlights these hazards should be conducted before every takeoff.
    - It is crucial to not become so focused on performing the maneuver that an unsafe situation is created. Maintain situational awareness, make appropriate radio calls, and ensure that takeoff clearance is obtained before entering any runways, if at a controlled field. **Vigilance must be maintained to avoid taxiing onto any intersecting runways beyond other hold short lines.** At uncontrolled fields, clearly communicate your taxi and takeoff 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!**
    - If the airplane is not accelerating as expected and the takeoff is in doubt, **abort!**

Maneuver Description

- **Selecting a Suitable Runway** - Select a runway that will allow takeoff into the wind, or with a manageable crosswind.
- **Checklists** - Pilots must perform a before-takeoff checklist before beginning the maneuver, and thoroughly brief any hazards that may be present on departure.
- **Before Takeoff** - Configure the airplane for takeoff (per the POH).
- **Entering the Runway** - Taxi into the runway, and line up with the centerline. Apply full power, take your toes off the toe brakes, and keep the airplane aligned with the runway using the rudder.
- **Takeoff Roll and Liftoff** - Allow the airplane to accelerate but **do not allow the airplane to lift off before rotation speed**. Be prepared to counteract the significant amount of left-turning tendencies with right rudder during takeoff roll. Positive aircraft control must be maintained at all times! **Apply *and hold* proper crosswind corrections to avoid sidewards drifting.**



- **Climbout** - Once the airplane has accelerated to rotation speed, rotate and accelerate to and climb at Vy. Make sure to fly coordinated. **More right rudder!**
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and ensure proper tracking of the centerline. *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 takeoff maneuver and how the various factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
    - Pilot configures the airplane properly for takeoff, performs a pre-takeoff checklist, ensures that takeoff clearance is obtained (at a towered airport) or that the runway and final approach path is clear (at a non-towered airport), and makes the appropriate radio calls.
    - Pilot taxis onto the runway, and aligns with the centerline.
    - Pilot applies full power, verifies proper engine indications, and remains on the ground until rotation speed.
    - Pilot accelerates to rotation speed, rotates, and climbs out at Vy +10/-5 knots.
    - Pilot divides attention between accurate, *coordinated airplane control* and outside visual references.