

## VII.B. Short-Field Takeoff and Maximum Performance Climb

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**References:** [Airplane Flying Handbook](#) (FAA-H-8083-3), POH/AFM

Objectives	The student should develop knowledge of the elements related to short field takeoffs and maximum performance climbs. The student will have the ability to demonstrate a short field takeoff and climb as prescribed in the necessary ACS/PTS.
Key Elements	<ol style="list-style-type: none"><li>1. Use the Entire Runway</li><li>2. Maximum Performance Climb at <math>V_x</math></li><li>3. Focus Outside the Airplane</li></ol>
Elements	<ol style="list-style-type: none"><li>1. <a href="#">V<sub>x</sub> (Best Angle of Climb Airspeed)</a></li><li>2. <a href="#">Runway Incursion Avoidance</a></li><li>3. <a href="#">Pre-Takeoff</a></li><li>4. <a href="#">Takeoff Roll</a></li><li>5. <a href="#">Lift-Off</a></li><li>6. <a href="#">Maximum Performance Climb</a> <a href="#">Common Errors, PTS/ACS Requirements</a></li></ol>
Schedule	<ol style="list-style-type: none"><li>1. Discuss Objectives</li><li>2. Review material</li><li>3. Development</li><li>4. Conclusion</li></ol>
Equipment	<ol style="list-style-type: none"><li>1. White board and markers</li><li>2. References</li></ol>
IP's Actions	<ol style="list-style-type: none"><li>1. Discuss lesson objectives</li><li>2. Present Lecture</li><li>3. Ask and Answer Questions</li><li>4. Assign homework</li></ol>
SP's Actions	<ol style="list-style-type: none"><li>1. Participate in discussion</li><li>2. Take notes</li><li>3. Ask and respond to questions</li></ol>
Completion Standards	The student shows the ability to execute a proper short-field takeoff and climb by using the entire runway, after rotation pitching immediately for $V_x$ until clear of obstacles, then pitching for $V_y$ .

**Instructor Notes:**

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**Introduction:**

**Attention**

Interesting fact or attention-grabbing story

Maximum Performance Takeoff and Climb... this is the mother of all takeoffs, where we put the airplane at its limits to obtain the most performance out of the airplane.

**Overview**

Review Objectives and Elements/Key ideas

**What**

Takeoffs and climbs from fields where the takeoff area is short or the available takeoff area is restricted by obstructions requiring the pilot to operate the airplane at the limit of its takeoff performance capabilities.

**Why**

Short Field Takeoffs develop the pilot's ability to operate the airplane at its maximum takeoff performance capabilities. This develops a better feel for the plane and results in improved takeoffs and airplane control.

**How:**

**1.  $V_x$  (Best Angle-of-Climb Speed)**

- A. To accomplish this takeoff safely, a pilot must have knowledge of  $V_x$ , the best angle-of-climb speed
- B.  $V_x$  is the speed which will provide the greatest gain in altitude for a given distance over the ground
  - i. It is usually slightly less than  $V_y$ , which provides the greatest gain in altitude per unit of time
- C. \* $V_x$  is 58 knots (DA20)
- D. Small deviations (5 knots) in some airplanes will result in a significant reduction in climb performance
  - i. Precise control of airspeed has an important bearing on the execution/safety of the maneuver

**2. Runway Incursion Avoidance**

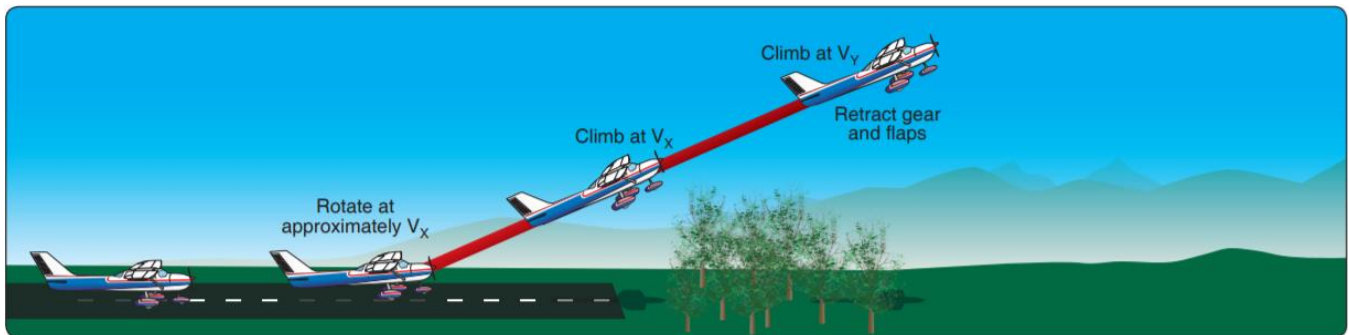
- A. Controlled Airport
  - i. Request and receive the appropriate clearance to taxi
  - ii. Request and receive the appropriate clearance before crossing any hold short bars onto a runway
  - iii. Have a taxi diagram available for use
  - iv. In the case of confusion, query the controller
  - v. Stop the airplane, if necessary, to prevent an incursion
- B. Uncontrolled Airport
  - i. Announce intentions on the CTAF when taxiing to alert other aircraft of your position and intentions
  - ii. Use the other aircraft's radio calls to build a mental picture of the traffic in the area and how they may affect you
  - iii. Check Final Approach

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- a. Before taxiing onto the runway, ensure you have time to takeoff before any aircraft make the turn onto final
        - As a general rule, don't take the runway with another airplane on final
      - b. A 360° turn on the ground in the direction of the traffic pattern is recommended to check for traffic at uncontrolled fields
    - iv. Check the Runway
      - a. Before taxiing out, ensure the runway is clear of other aircraft, vehicles, persons, or other hazards
  - C. **Common Error** - Improper runway incursion avoidance
3. **Pre-Takeoff**
  - A. \*In the case of the DA20, the airplane should be configured for a normal takeoff
4. **Takeoff Roll**
  - A. Start at the very beginning of the takeoff area. The field is short, don't waste any runway
    - i. Align the airplane with the runway centerline/intended takeoff path and come to a complete stop
    - ii. Apply and adjust any necessary crosswind correction as would be done in a normal takeoff
  - B. Smoothly and continuously, without hesitation, advance the throttle to maximum power
    - i. Some pilots prefer to hold the brakes and establish maximum power before beginning the takeoff roll, however it has not been established that this procedure results in a shorter takeoff run in all general aviation airplanes
      - a. Follow the manufacturer's procedures
    - ii. Check the instruments/gauges and announce "airspeed alive," and "engine gauges green," or abort the takeoff
      - a. Do not hesitate to abort the takeoff if there is a problem with either the airspeed or engine gauges
  - C. Maintain directional control with the rudders
    - i. Use right rudder to counteract the left turning tendencies
  - D. The airplane should be allowed to roll with full weight on the main wheels and accelerate to liftoff speed
    - i. \*Short Field  $V_R$  – 52 knots
    - ii. As the takeoff roll progresses, the pilot must adjust the pitch attitude/angle of attack to attain minimum drag and maximum acceleration
      - a. This involves little use of the elevator (neutral position) since the airplane is already in a low drag attitude
  - E. **Common Error** - Improper use of controls during a short-field takeoff
    - i. Maintain crosswind controls as in a normal takeoff
    - ii. Keep the elevator neutral to minimize drag
5. **Lift-Off**
  - A. \*Smoothly and firmly rotate the airplane at  $V_R$  (52 knots) to the pitch attitude that will result  $V_X$  climb
    - i. Use outside references and pitch on the attitude indicator to maintain the correct attitude
      - \*Approximately 12° nose up (slightly steeper than a normal takeoff)
    - ii. In the case the airplane lifts off prior to  $V_R$ , allow the airplane to accelerate in ground effect to  $V_X$ 
      - a. Similar to a soft-field takeoff – the airplane should be held in ground effect, with the wheels just clear of the runway surface
        - This is preferable to forcing the airplane to remain on the ground with forward pressure

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- a. Holding the airplane on the ground puts excessive pressure on the nosewheel and can result in “wheel barrowing,” while reduces acceleration and performance
  - b. Do not intentionally raise the nose prior to  $V_R$ , this will increase drag and prolong the roll
    - A premature lift-off/too steep a climb may result in settling onto the runway or a collision with the obstacle
      - a. Even if the airplane remains airborne, the initial climb will remain flat and climb performance and obstacle clearance are severely degraded until reaching  $V_X$
  - B. Once airborne, a wings level climb should be maintained at  $V_X$  until obstacles have been cleared
    - i. Since the airplane accelerates more rapidly after liftoff, more back pressure is required to hold airspeed
      - a. Airspeed is increasing rapidly, therefore pitch will have to be increased to maintain  $V_X$
  - C. **Common Error** - Improper liftoff procedures
- 6. Maximum Performance Climb**
- A. Climb out at  $V_X$  until clear of obstacles
    - i. Maintain visual references, but occasionally glance at the attitude and airspeed indicators to check pitch and  $V_X$
  - B. Configuration is not changed until clear of obstacles (unless recommended by the manufacturer)
    - i. The pilot should not be in the cockpit reaching for gear/flap controls until clear of the obstacle
  - C. \*Once clear of obstacles pitch for  $V_Y$  (65 knots)
    - i. Visually – Normal takeoff climb picture
    - ii. Once stabilized at  $V_Y$ , configure the airplane per the POH, complete the climb checklist as normal
      - a. Usually advisable to raise the flaps in increments to avoid sudden loss of lift and settling of the airplane
  - D. **Common Error** - Improper initial climb attitude, power setting, and airspeed ( $V_X$ ) to clear obstacle
    - i. Pitch for the approximate attitude for  $V_X$ , make small adjustments from there to maintain the airspeed
    - ii. Maximum power should be used for maximum performance
      - a. Ensure the mixture is properly adjusted for takeoff
  - E. **Common Error** - Improper use of checklists
    - i. Fly first, only begin checklists when safely climbing and clear of obstacles



### Common Errors:

- Improper runway incursion avoidance

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- Improper use of controls during a short-field takeoff
- Improper lift-off procedures
- Improper initial climb attitude, power setting, and airspeed ( $V_x$ ) to clear obstacle
- Improper use of checklist

### **Conclusion:**

Brief review of the main points

The short-field takeoff and maximum performance climb is based on rotating and pitching directly for  $V_x$ . This allows for the greatest climb in the shortest distance, providing the most effective obstacle clearance.

### **PTS Requirements:**

To determine that the applicant:

1. Exhibits instructional knowledge of the elements of a short-field takeoff and climb by describing:
  - a. Procedures before taxiing onto the runway or takeoff area to ensure runway incursion avoidance. Verify ATC clearance/no aircraft on final at non-towered airports before entering the runway, and ensure that correct takeoff runway positioning of the airplane with consideration for other aircraft, surface conditions, and wind.
  - b. Short-field takeoff and lift-off procedures.
  - c. Initial climb attitude and airspeed ( $V_x$ ) until obstacle is cleared (50 feet AGL).
  - d. Proper use of checklist.
2. Exhibits instructional knowledge of common errors related to a short-field takeoff and climb by describing:
  - a. Improper runway incursion avoidance procedures.
  - b. Improper use of controls during a short-field takeoff.
  - c. Improper lift-off procedures.
  - d. Improper initial climb attitude, power setting, and airspeed ( $V_x$ ) to clear obstacle.
  - e. Improper use of checklist.
3. Demonstrates and simultaneously explains a short-field takeoff and climb from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to a short-field takeoff and climb.

### **Private Pilot ACS Skills Standards**

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Verify assigned/correct runway.
4. Ascertain wind direction with or without visible wind direction indicators.
5. Position the flight controls for the existing wind.
6. Clear the area, taxi into takeoff position and align the airplane on the runway centerline utilizing maximum available takeoff area.
7. Apply brakes while setting aircraft power to achieve maximum performance.
8. Confirm takeoff power prior to brake release and verify proper engine and flight instrument indications prior to rotation
9. Rotate and lift off at the recommended airspeed and accelerate to the recommended obstacle clearance airspeed or  $V_x +10/-5$  knots.
10. Establish a pitch attitude that will maintain the recommended obstacle clearance speed, or  $V_x +10/-5$  knots, until the obstacle is cleared, or until the airplane is 50 feet above the surface.

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11. Establish a pitch attitude for  $V_Y$  and accelerate to  $V_Y + 10/-5$  knots after clearing the obstacle or at 50 feet AGL if simulating an obstacle.
12. Configure the airplane in accordance with manufacturer's guidance after a positive rate of climb has been verified.
13. Maintain  $V_Y + 10/-5$  knots to a safe maneuvering altitude.
14. Maintain directional control and proper wind drift correction throughout takeoff and climb.
15. Comply with noise abatement procedures.

### **Commercial Pilot ACS Skills Standards**

1. Complete the appropriate checklist.
2. Make radio calls as appropriate.
3. Verify assigned/correct runway.
4. Ascertain wind direction with or without visible wind direction indicators.
5. Position the flight controls for the existing wind conditions.
6. Clear the area, taxi into takeoff position and align the airplane on the runway centerline utilizing maximum available takeoff area.
7. Apply brakes while setting aircraft power to achieve maximum performance.
8. Confirm takeoff power prior to brake release and verify proper engine and flight instrument indications prior to rotation.
9. Rotate and lift off at the recommended airspeed and accelerate to the recommended obstacle clearance airspeed or  $V_X \pm 5$  knots.
10. Establish a pitch attitude that will maintain the recommended obstacle clearance airspeed or  $V_X \pm 5$  knots until the obstacle is cleared or until the airplane is 50 feet above the surface.
11. Establish a pitch attitude for  $V_Y$  and accelerate to  $V_Y \pm 5$  knots after clearing the obstacle or at 50 feet AGL if simulating an obstacle.
12. Configure the airplane in accordance with the manufacturer's guidance after a positive rate of climb has been verified.
13. Maintain  $V_Y \pm 5$  knots to a safe maneuvering altitude.
14. Maintain directional control and proper wind-drift correction throughout takeoff and climb.
15. Comply with noise abatement procedures.