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

References: 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 PTS.

Key Elements
1. Use the Entire Runway
2. Maximum Performance Climb at $V_X$
3. Focus Outside the Airplane

Elements
1. $V_X$ (Best Angle of Climb Airspeed)
2. Runway Incursion
3. Pre-Takeoff
4. Takeoff Roll
5. Lift-Off
6. Maximum Performance Climb

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 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, at which time he will pitch for $V_Y$. 
Instructors Notes:

Introduction:
Attention
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 T/O safely a pilot must have knowledge of $V_X$, the best angle-of-climb speed
   B. $V_X$ is 82 knots
   C. $V_X$ 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
   D. Small deviations (5 knots) in some airplanes will result in a significant reduction in climb performance
      i. Precise control of AS has an important bearing on the execution/safety of the maneuver
2. Runway Incursion Avoidance
   A. Check Final Approach
      i. Before taxiing onto the runway, ensure you have time to takeoff before any aircraft turn onto final
      ii. A 360° turn on the ground in the direction of the traffic pattern is recommended to check for traffic
   B. Check the Runway
      i. Before taxiing out, ensure the runway is clear of other aircraft, vehicles, persons, or other hazards
   C. 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
   D. Uncontrolled Airport
      i. Announce intentions on the CTAF
3. Pre-Takeoff
   A. In the case of the DA42, the airplane should be configured for a normal takeoff
4. Takeoff Roll
   A. Start at the very beginning of the 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 throughout as would be done in a normal T/O
   B. Hold the brakes while smoothly advancing the throttle to maximum power
      i. Check engine gauges GREEN
   C. Release the brakes
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i. Maintain directional control with the rudders
   a. Anticipate torque pulling the aircraft to the left
ii. Announce “Airspeed Alive,” and “Engine Gauges are Green”
   a. Do not hesitate to abort the takeoff if there is a problem with either the AS or engine gauges
iii. The airplane should be allowed to roll with full weight on the mains and accelerate to liftoff speed

5. Lift-Off
   A. Smoothly and firmly rotate the airplane at $V_R$ immediately to an attitude that will result in $V_X$
      i. Use outside references and pitch on the AI to maintain/remember the correct attitude
         • Approximately $12^\circ$ nose up (slightly steeper than a normal takeoff)
      ii. In the case the airplane lifts off early, allow the airplane to accelerate in ground effect
         a. 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 obstacle
            Even if the airplane remains airborne, the initial climb will remain flat and climb performance and obstacle clearance are severely degraded until reaching $V_X$
      iii. Since the airplane accelerates more rapidly after liftoff, more back pressure is required to hold AS
         a. AS is increasing rapidly, therefore pitch will have to be increased to maintain airspeed
   B. Once airborne, a wings level climb should be maintained at $V_X$ until obstacles have been cleared

6. Maximum Performance Climb
   A. Climb out at $V_X$ until clear of obstacles
      i. Maintain visual references, but occasionally glance at the AI and ASI to check pitch angle and AS
   B. Configuration is not changed until clear of obstacles
      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 $V_Y$
      i. Visually – Normal takeoff climb site picture
         • Once stabilized at $V_Y$, the climb checklist can be completed as normal

Common Errors:
- Improper runway incursion avoidance
  o Do not taxi on the runway until cleared to T/O or position and hold and are sure the area is clear
- Improper use of controls during a short-field takeoff
  o Crosswind – Full aileron should be held into the wind initially and gradually decreased with AS
- Improper lift-off procedures
  o Excessive back pressure will result in an excessively high pitch attitude and delay T/O or settling
  o Not enough back pressure may result in insufficient lift and the airplane settling onto runway
  o Improper trim settings will make it more difficult to maintain the proper takeoff attitude
- Improper initial climb attitude, power setting, and airspeed ($V_X$) to clear obstacle
  o Use the POH to determine the proper configuration and airspeed
  o Do not retract flaps until clear of obstacles
  o Maintain $V_X$ until clear of obstacles then accelerate and maintain $V_Y$
  o Maintain pitch attitude by outside references; cross check with the ASI and AI
- Improper use of checklist

Conclusion:
Brief review of the main points
The short-field takeoff and maximum performance climb is based on rotating near and pitching directly for $V_X$. This allows for the greatest climb in the shortest distance, providing obstacle clearance.
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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 you are on the correct takeoff runway positioning the airplane with consideration for other aircraft, surface conditions, and wind.
   b. short-field takeoff procedures.
   c. short-field lift-off procedures.
   d. initial climb attitude and airspeed (VX) until obstacle is cleared (50 feet AGL).
   e. 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 (VX) 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.