

IX.A. Steep Turns

References: FAA-H-8083-3

Objectives	The student should develop knowledge of the elements related to steep turns (load factors, torque, adverse yaw, and the overbanking tendency). The student should have the ability to perform a steep turn as required in the PTS.
Key Elements	<ol style="list-style-type: none">1. Overbanking Tendency2. Coordination3. Increased back pressure and thrust are required to maintain altitude4. Maintain altitude with elevators and bank angle
Elements	<ol style="list-style-type: none">1. The Science Behind It2. Performing the Steep Turn
Schedule	<ol style="list-style-type: none">1. Discuss Objectives2. Review material3. Development4. Conclusion
Equipment	<ol style="list-style-type: none">1. White board and markers2. References
IP's Actions	<ol style="list-style-type: none">1. Discuss lesson objectives2. Present Lecture3. Ask and Answer Questions4. Assign homework
SP's Actions	<ol style="list-style-type: none">1. Participate in discussion2. Take notes3. Ask and respond to questions
Completion Standards	The student understands the characteristics behind the factors involved in the steep turn and can properly perform them in both directions maintaining altitude and airspeed.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

Steep turns - the first really fun maneuver! Steep banks, you feel some G's and you're staring at the ground out the side window!

Overview

Review Objectives and Elements/Key ideas

What

The steep turn maneuver consists of a constant altitude turn in either direction, using a bank angle between 45° to 60° (45° - Private, or 50° - Commercial). This will cause an overbanking tendency during which maximum turning performance is attained and relatively high load factors are imposed.

Why

Steep turns develop smoothness, coordination, orientation, division of attention, and control techniques necessary for the execution of maximum performance turns. The pilot also understands the effects of the over banking tendency and how to counteract it.

How:

1. The Science Behind It

- A. An airplane's maximum turning performance is its fastest rate of turn and shortest radius of turn
 - i. This changes with both airspeed and angle of bank
 - ii. An airplane's turning performance is limited by the amount of power the engine is developing, its limit load factor and its aerodynamic characteristics
 - a. The maximum bank is determined by the limiting load factor which can be maintained without stalling or exceeding the airplane's structural limitations
 - In most small airplanes the max bank is approx 50° to 60°
- B. What makes an airplane turn?
 - i. As an aircraft banks lift is divided into a horizontal as well as a vertical component
 - a. The horizontal component of lift pulls the aircraft through the turn
- C. Load Factors
 - i. High loads are imposed on an airplane as the bank is increased beyond 45°
 - a. At a 60° bank, a load factor of 2 Gs are imposed on the aircraft structure
 - b. At a 70° bank, a load factor of approximately 3 Gs are placed on the aircraft
 - Most general aviation airplanes are stressed for approximately 3.8 Gs
 - ii. Regardless of the airspeed or type of aircraft involved, a given angle of bank in a turn, during which altitude is maintained, will always produce the same load factor
 - a. EX: 60° of bank will always produce 2 G's, irrespective of airspeed, aircraft, power setting, etc.
 - iii. Increases in the load factor increase the stalling speed at a significant rate
 - a. Stalling speed increases at the square root of the load factor
 - EX. A plane that stalls at 60 knots in level flight will stall at nearly 85 knots in a 60° bank
 - b. Understanding/observing this fact is an indispensable safety precaution for the performance of all maneuvers requiring turns
- D. Adverse Yaw

IX.A. Steep Turns

- i. In a turn, the downward deflected aileron produces more lift, and therefore more drag
 - a. This added drag attempts to yaw the airplane's nose in the direction of the raised wing
 - ii. The rudder is used to counteract adverse yaw
 - a. The amount of rudder control required increases at low airspeeds, high angles of attack, and with large aileron deflections
 - With lower airspeeds, the vertical stabilizer/rudder combination becomes less effective, therefore magnifying the control problems associated with adverse yaw
- E. Torque Effect
- i. The internal engine parts and propeller are revolving in one direction, an equal force is trying to rotate the airplane in the opposite direction
 - a. Newton's 3rd Law
 - b. This force acts around the longitudinal axis, tending to make the airplane roll to the left
 - ii. Left Turn
 - a. Due to the torque effect, there is a tendency to develop a skid
 - May need less left rudder (or more right rudder) to maintain coordinated flight
 - a. In a left turn, adverse yaw acts in concert with other yawing moments to exaggerate the skid
 - iii. Right Turn
 - a. Torque effect results in a tendency to develop a slip
 - May need to add right rudder to maintain coordinated flight
 - a. In a right turn, adverse yaw acts in opposition to other yawing moments to minimize the slipping tendency
- F. Over-Banking Tendency
- i. Over-banking tendency is the result of the aircraft being banked steeply enough to reach a condition of negative static stability about the longitudinal axis
 - a. Static Stability refers to the initial response of a system to a disturbance
 - b. Static stability can be positive, neutral, or negative
 - Static Stability is the tendency of the aircraft, once displaced, to try to return to the stable condition as it was before being disturbed
 - a. In a shallow turn, the airplane displays positive static stability
 1. Initially tries to return to a wings level attitude
 - b. In a medium banked turn, the airplane shows neutral stability
 1. The airplane will remain in the bank
 - c. In a steep turn, the airplane demonstrates negative static stability
 1. The airplane will try to steepen the bank rather than remain stable
 2. This is the over-banking tendency (more info below - part iii)
 - ii. There is a limited amount of positive static stability around the longitudinal axis so that the airplane will be easy to turn but will return to straight and level flight from shallow banks
 - a. This lateral stability about the longitudinal axis is affected by:
 - Dihedral
 - Sweepback Angles
 - Keel Effect
 - Weight Distribution
 - b. Dihedral is the angle at which the wings are slanted upward from the root to the tip
 - Dihedral involves a balance of lift created by the wings' angle of attack on each side of the airplane's longitudinal axis
 - a. The airplane tends to sideslip or slide downward toward the lowered wing

IX.A. Steep Turns

- iv. Establish the manufacturer's recommended entry airspeed or the design maneuvering speed
 - v. Ensure the aircraft is in straight and level flight
 - a. Entering in a climb or descent will create extra work during the maneuver
- B. Entering the Turn
- i. Note the entry heading
 - ii. Smoothly roll into the selected bank angle
 - a. 45° (Private)
 - b. 50° (Commercial)
 - c. Apply rudder as necessary to maintain coordination
 - d. Establish opposite aileron as necessary to maintain the bank angle through the maneuver
 - iii. As the turn is established, smoothly introduce back elevator pressure to increase the angle of attack
 - a. A good technique is to begin increasing back pressure when passing 30° of bank
 - b. The back pressure provides the additional wing lift required to compensate for the increasing load factor as well as the reduced vertical component of lift
 - c. Trim the airplane of excess control pressures
 - iv. Power must be added to maintain the entry altitude and airspeed
 - a. Additional back-elevator pressure increases the angle of attack, which results in an increase in drag, requiring added power
 - b. Begin increasing power as required when passing approximately 30° of bank as well
 - v. **CE** - Improper pitch, bank, and power coordination during entry
- C. During the Turn
- i. Do not focus or stare at any one object
 - a. To maintain altitude, as well as orientation, you must have an awareness of the relative position of the nose, the horizon, the wings, and the amount of bank
 - Only watching the nose will result in difficulty holding altitude constant
 - Watching the nose, horizon, and the wings can result in holding altitude within a few feet
 - b. **CE** - Loss of orientation
 - Note the entry heading
 - Occasionally glance at the heading indicator to know where you are in the turn
 - ii. Adjustments
 - a. Increasing/decreasing altitude
 - Maintain Bank Angle
 - a. The over-banking tendency will require opposite aileron pressure to maintain your desired bank angle
 - Relax or increase the back elevator pressure as appropriate
 - a. Power should be adjusted accordingly to maintain the entry airspeed
 - Small increase or decrease of 1° to 3° of bank angle may be used to control small altitude deviations
 - a. Increasing the bank angle decreases lift
 - b. Decreasing the bank angle increases lift
 - If the aircraft is descending and bank angle is excessive, reducing the bank angle may stop the descent
 - a. Make further corrections once bank has been reestablished
 - If ascending and the bank angle is shallow, increasing the bank angle may correct the altitude deviation
 - a. Make further corrections once bank has been reestablished
 - b. **CE** - Improper procedure in correcting altitude deviations

IX.A. Steep Turns

- Use bank and pitch as necessary in order to correct for deviations in altitude
- **CE** - Uncoordinated use of flight controls
 - c. Rudder pressure will be necessary to maintain coordination during the maneuver
 - Introducing rudder pressure part way through the turn can have adverse effects on altitude
- D. Rolling out of the Turn
 - i. The rollout should be timed so that the wings reach level flight when the airplane is exactly on the heading from which the maneuver was started
 - a. General rule: Begin the rollout when approximately $\frac{1}{2}$ the bank angle from your entry heading
 - $20^\circ - 25^\circ$ prior to your entry heading
 - ii. While the rollout is being made, back-elevator pressure is gradually released and power reduced, as necessary, to maintain altitude and airspeed
 - a. If the elevator was trimmed up for the turn ensure the trim is removed on the rollout to prevent a large increase in altitude as wings return level increasing the vertical component of lift
 - iii. **CE** - Improper pitch, bank, and power coordination during entry and rollout

Common Errors:

- Improper pitch, bank, and power coordination during entry and rollout
- Uncoordinated use of flight controls
- Improper procedure in correcting altitude deviations
- Loss of orientation

Conclusion:

Brief review of the main points

In maintaining a properly coordinated steep turn, the pilot must use opposite aileron to maintain bank. Pitch should be controlled by adjusting elevator back pressure and bank angle. A smaller bank angle will result in more lift while an increased bank angle will reduce the lift. Maintaining coordination is very important and should be watched carefully throughout the maneuver.

PTS Requirements:

To determine that the applicant:

1. Exhibits instructional knowledge of the elements of steep turns by describing:
 - a. Relationship of bank angle, load factor, and stalling speed.
 - b. Overbanking tendency.
 - c. Torque effect in right and left turns.
 - d. Selection of a suitable altitude.
 - e. Orientation, division of attention, and planning.
 - f. Entry and rollout procedure.
 - g. Coordination of flight and power controls.
 - h. Altitude, bank, and power control during the turn.
 - i. Proper recovery to straight-and-level flight.
2. Exhibits instructional knowledge of common errors related to steep turns by describing:
 - a. Improper pitch, bank, and power coordination during entry and rollout.
 - b. Uncoordinated use of flight controls.
 - c. Improper procedure in correcting altitude deviations.
 - d. Loss of orientation.
3. Demonstrates and simultaneously explains steep turns from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to steep turns.