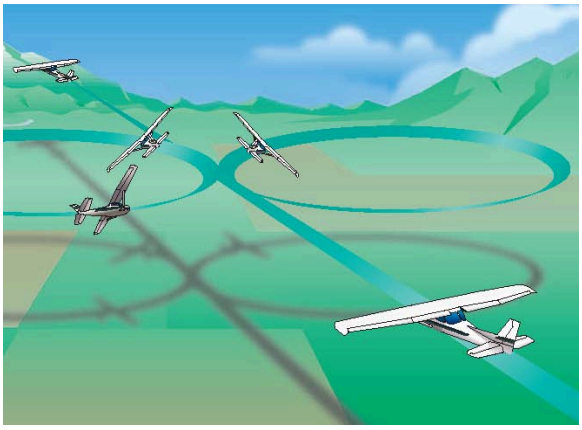
Steep Turns

Objective

To ensure the applicant understands and can exhibit a clear understanding of the steep turns maneuver and how to perform it properly.

Purpose

The steep turn is a maximum performance level turn that demonstrates the increase in load factor of steeply banked level turns, the necessity of increasing back elevator pressure to compensate for the loss of vertical lift, overbanking tendencies, and requires pilots to have an understanding of maneuvering speed and accelerated stalls.



Schedule

- **Ground Lesson**: 15 minutes
- Initial
  - **Flight 1**: 30 minutes - *Introduction to Maneuver*
  - **Flight 2**: 30 minutes - *Improve Proficiency (Dual)*
- Solo
  - **Flight 3**: 20 minutes - *Improve Proficiency*
- Pre-Checkride
  - **Flight 4**: 20 minutes - *Demonstrate Proficiency*
- **Debrief**: 10 minutes (*per flight*)

Equipment

- Airplane POH and Checklist
- Whiteboard / Markers (optional)
- Model Airplane (optional)

Student Actions

- Ask any questions, receive study material for the next lesson.
- Watch linked video.
- Review listed references.

Instructor Actions

- 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.
- **Flight**: Student can perform the maneuver to the applicable ACS standards.
  - See expanded Completion Standards below.

References

- The UND AeroCast - Commercial Steep Turns
  - YouTube: https://www.youtube.com/watch?v=24LySNN3SCE
- FAA-H-8083-3C (Airplane Flying Handbook) - Chapter 10, Page 1-3 [Steep Turns Maneuver Description], Chapter 3, Page 14 [Turn Radius, Overbanking Tendency]
- FAA-H-8083-25C (Pilot's Handbook of Aeronautical Knowledge) - Chapter 5, Page 22-23 [Forces in Turns], Chapter 5, Page 30-33 [Left Turning Tendencies], Chapter 5, Page 39 [Turn Radius], Chapter 5, Page 34-35 [Load Factors and Stalling Speeds], Chapter 5, Page 37-38 [Vg Diagram], Chapter 5, Page 20 [Spiral Instability]
- FAA-S-ACS-6C (Private Pilot ACS) - Area V Task A
- FAA-S-ACS-7B (Commercial Pilot ACS) - Area V Task A
- FAA-S-ACS-25 (CFI ACS) - Area IX Task A

Ground Lesson Outline

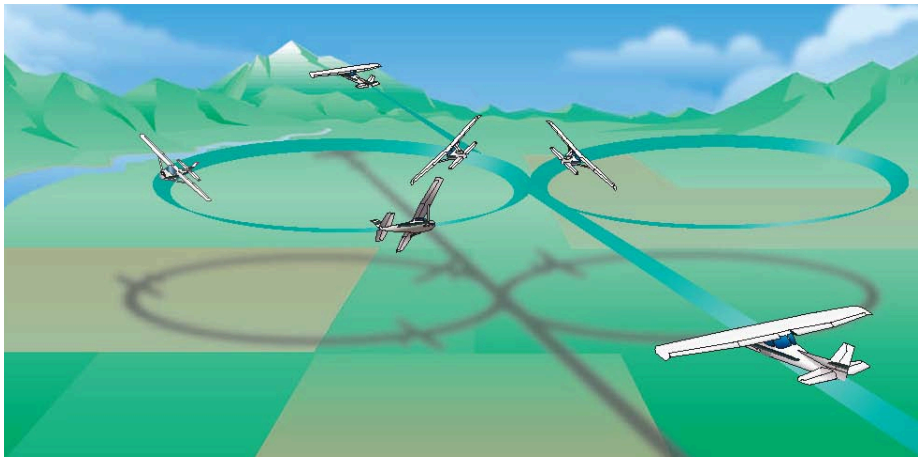
- Maneuver Overview
- Bank Angle and Load Factor
  - Load factor depends on bank angle - Feeling of increased weight
  - Increased AoA required
  - Induced drag increased
- Overbanking Tendency
- Left Turning Tendencies
  - Differences between left and right turns
- Effect on Stall Speed / Accelerated Stalls
  - Vg Diagram
- Safety considerations
  - Use of checklists
  - Visual traffic scanning
- Maneuver Description - step-by-step
  - Entry position, airspeed, etc.
- Expanded Completion Standards

Common Errors

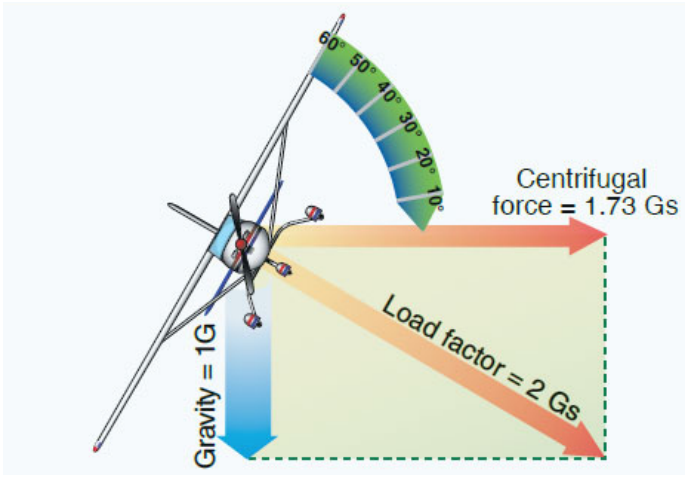
- Not clearing the area
- Inadequate pitch control on entry or rollout
- **Gaining altitude or losing altitude**
- **Failure to maintain constant bank angle**
- Poor flight control coordination
- Ineffective use of power or trim
- Inadequate airspeed control
- Becoming disoriented
- **Performing by reference to the flight instruments rather than visual references**
- Failure to scan for other traffic during the maneuver
- Attempts to start recovery prematurely
- **Failure to stop the turn on designated heading**

Ground Lesson Content

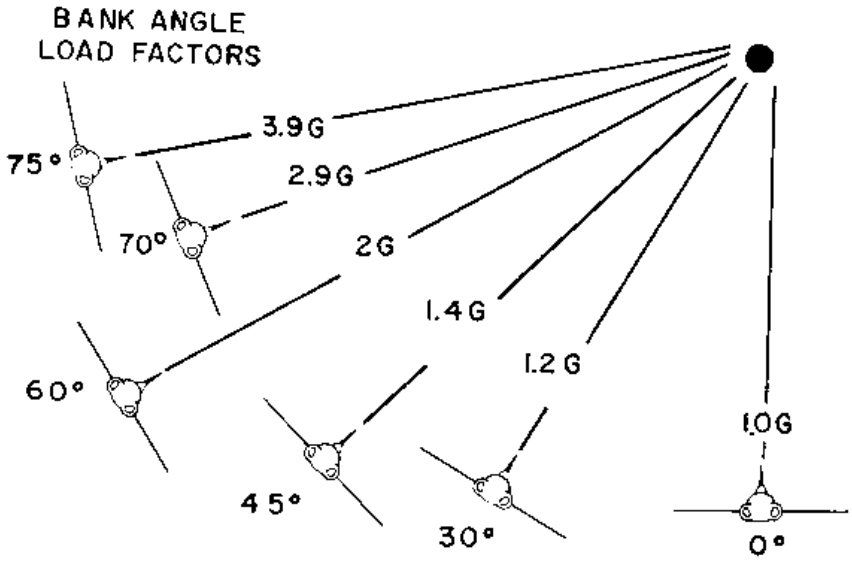
- **Maneuver Overview** - The steep turns maneuver is simply two steep, high-performance, level turns, performed back to back. The bank angle is chosen to be high enough to produce noticeably higher G-forces, as well as to make the aerodynamics that affect turning, high angle-of-attack flight more pronounced.



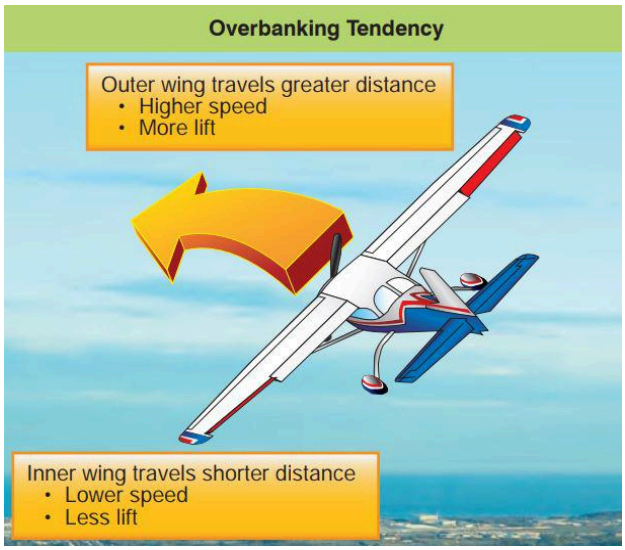
- **Bank Angle and Load Factor** - As an airplane turns, its weight remains the same, and therefore the upward component of lift must remain equal to its weight. During a turn, some of the lift must be directed towards the center of the turn, reducing the upward component of lift. If no pilot corrections were applied, the airplane would not produce any more than the normal 1g of lift, and the airplane would begin to descend. In order to correct for the loss of vertical lift, and maintain a level altitude, the wing must produce more lift, which requires increased *back elevator pressure*. This increased back elevator pressure will cause the wing to fly at a ***higher angle of attack***, producing the increased lift that is required. This can be felt by the pilot as a higher than normal G-force.
- Steep turns are simply normal, level turns that are made at a bank angle where the amount of total lift required is significantly higher than 1g. In order to maintain 1g of vertical lift, while also turning, the wing must produce more than 1g of total lift. The amount of total lift is called the ***load factor***.

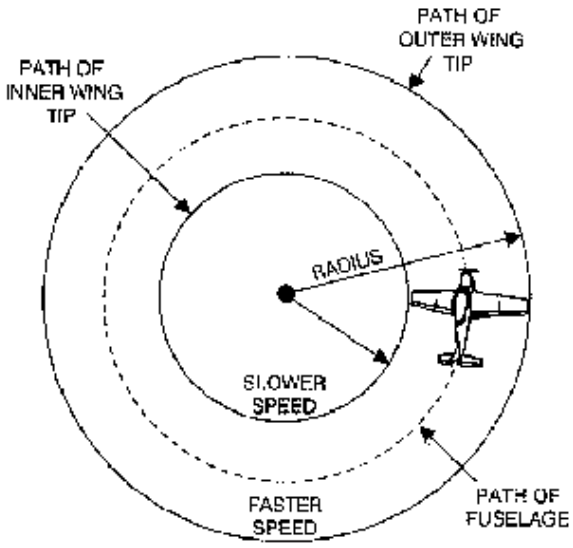


- As the bank angle increases, the load factor required to maintain level flight increases slowly at first, but increases rapidly, especially at bank angles beyond 45 degrees. The load factor created by a *level* turn depends only on the bank angle. Note that airspeed does not affect the load factor of a turn.



- While flying at a higher angle of attack necessary to meet the demands of a high load factor, the wing will produce more *induced drag*. This will result in the airspeed decreasing unless power is added to compensate for the increased drag.
- **Overbanking Tendency** - Aircraft flying with a high rate of turn also have a **strong overbanking tendency**. This is caused by the outside wing traveling a longer path than the inside wing, and therefore traveling at a slightly higher airspeed, and creating more lift. It may be necessary to apply opposite aileron to counteract the overbanking tendency during a tight turn.





- **Left-Turning Tendencies** - Because of the high power setting, increased load factor, and resulting increased angle of attack, airplanes performing steep turns are also subject to more pronounced left-turning tendencies. Specifically, a high power setting produces a high torque reaction, and the high angle of attack makes P-factor very pronounced, **especially in a steep turn to the right**. Rudder pressure to maintain coordinated flight may be significant.

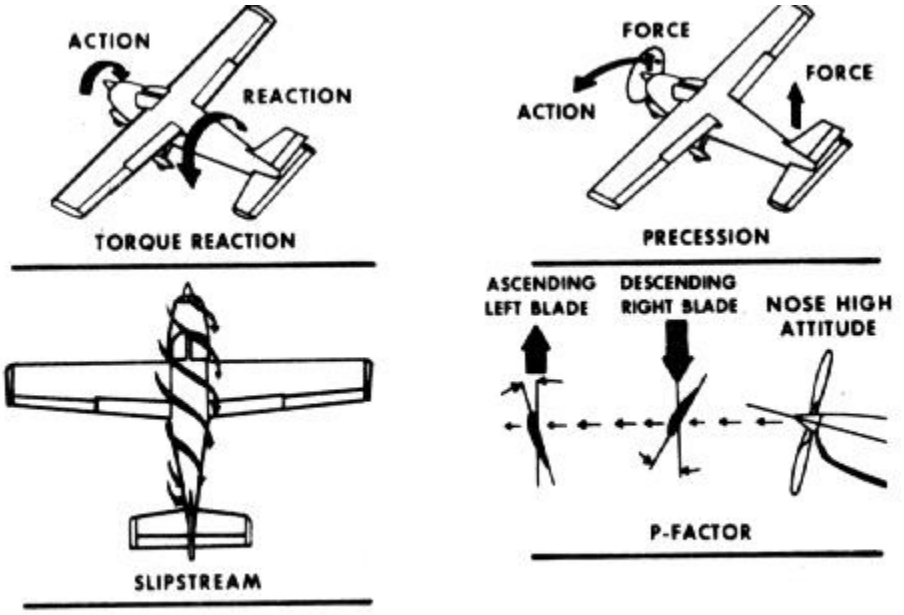
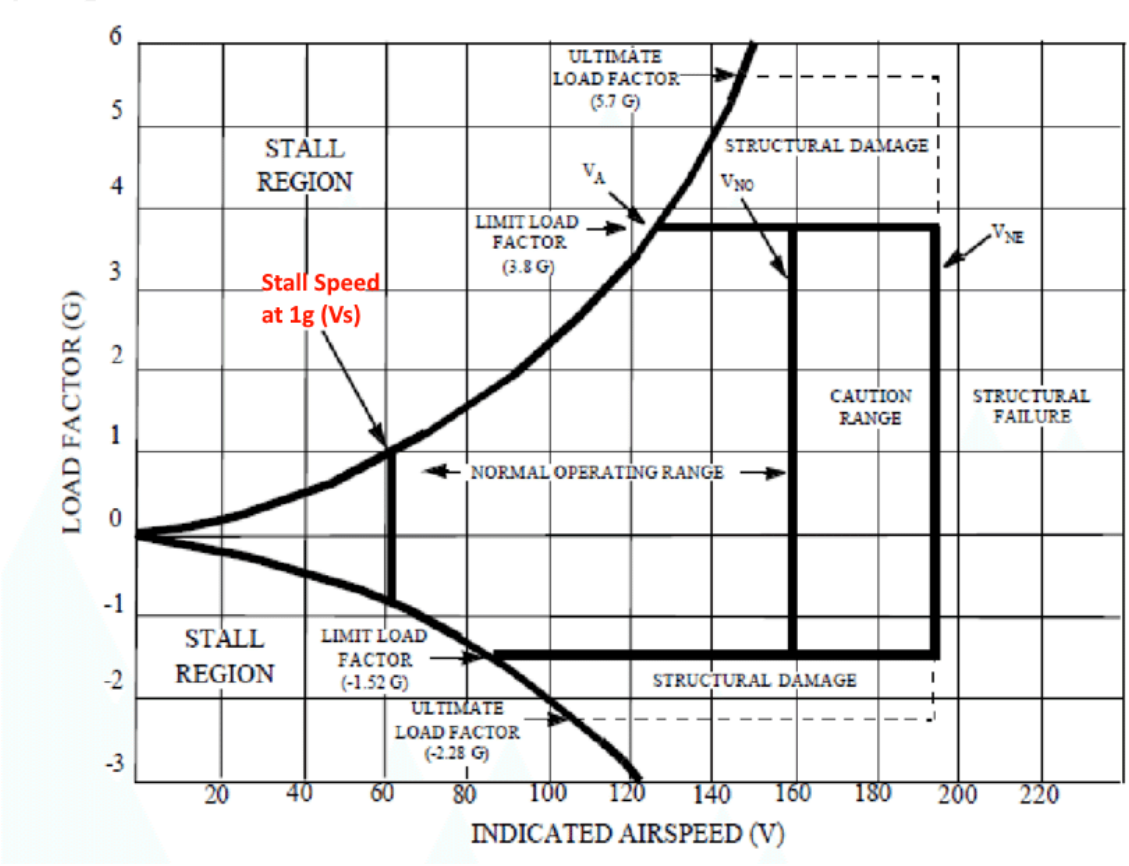


Figure 3–6 Left Turning Tendencies

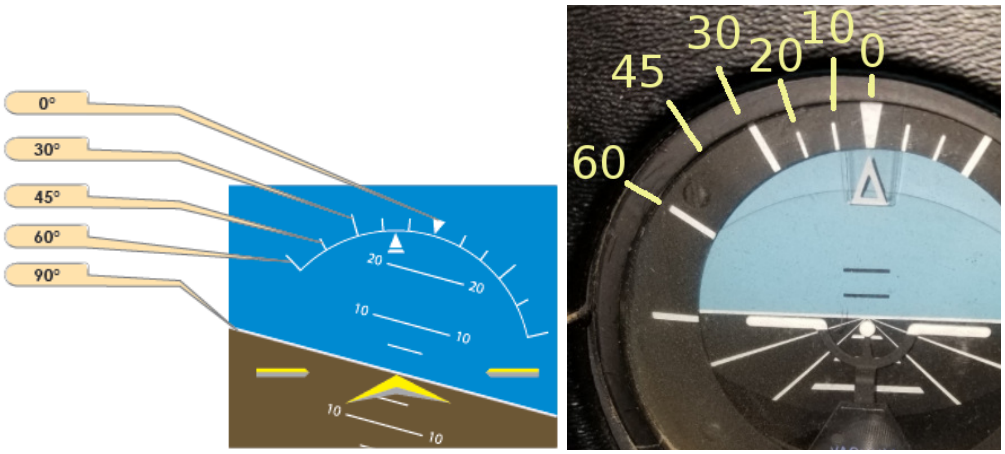
- **Effect on Stall Speed / Accelerated Stalls** - As the load factor increases in a steep turn, it is important to recognize that **the stall speed also increases**. We can see this relationship depicted in a so-called *Vg diagram*, shown below. The Stall Speed we normally see for our aircraft, Vs or Vs_0, applies only to 'unaccelerated' flight--that is, flight at 1g load factor. A stall that occurs above 1g is called an *accelerated stall*. Observe from the Vg diagram that as the load factor increases, the stall speed also increases. Eventually, it reaches a point called the *limit load factor*, which for a normal category airplane is +3.8G. The stall speed at this point is called **Va**, or *maneuvering speed*. Below this speed, the wing will exceed the critical AoA and stall before the aircraft suffers structural damage, however above this speed, structural damage may result. *It is critical to always perform steep turns below maneuvering speed!*



- **Safety Considerations**
  - **Checklists** - Pilots should complete a pre-maneuver checklist before beginning the maneuver.
  - **Visual Traffic Scanning** - Pilots must remember to keep up their traffic scan throughout the maneuver.

Maneuver Description

- **Entry Altitude** - While there is no officially established minimum altitude for the steep turn, for safety, a steep turn should be started *no lower than* **1,500ft** AGL.
- **Entry Speed** - Like all performance maneuvers, a steep turn must be started at less than **Va** (maneuvering speed). Typically a steep turn is entered in level cruise flight, at least 5-10 knots below Va.
- **Bank** - The bank angle should be smoothly increased to approximately **45** *degrees of bank* for Private Pilot applicants and **50** *degrees of bank* for Commercial and CFI applicants and held throughout the turn. Bank angle may be varied slightly (+/- 5 degrees) to help maintain altitude. Lack of adequate control over the bank angle will result in large climbs or descents. The bank angle is marked on the attitude indicator, note that some attitude indicators do not have a 45 degree mark:



- **Altitude** - Altitude should be maintained throughout the maneuver primarily by visual reference to the horizon and occasionally checked against the altimeter. The altitude must remain +/- **100** feet.
- **Airspeed** - Airspeed should remain within **10** knots of the entry airspeed. As the turn is started, passing 30 degrees of bank, it is necessary to add a little bit of power. If insufficient power is added, the airspeed will decay due to increased load factor, and an accelerated stall may occur. *If the stall horn sounds at any point in the maneuver, immediately recover!*
- **Recovery** - Begin a smooth roll out of the bank approximately 15-20 degrees of turn before you reach your entry heading. *Be ready to remove the power that was added* at the start of the maneuver to prevent climbing. Roll into an opposite direction turn, if requested.
- **Coordination** - Proper coordination is essential and should be maintained *at all times*. Do not attempt to tighten the turn with rudder. Uncoordinated flight creates the risk of a cross-controlled accelerated stall or spin.
- **This is a visual maneuver!** Eyes should remain outside the cockpit as much as possible to scan for traffic and to help monitor the aircraft attitude and the progress of the turn.

Expanded Completion Standards

- The pilot can explain the purpose of the steep turns maneuver and how the various factors affect the performance of the maneuver.
- The pilot can perform the maneuver to the following standards:
    - Pilot clears the area, performs a pre-maneuver checklist, establishes a speed below Va, and selects an altitude not less than 1,500ft AGL.
    - **Private Pilot**: Pilot rolls into a coordinated 360° steep turn with approximately a **45° bank**.
    - **Commercial Pilot/CFI**: Pilot rolls into a coordinated 360° steep turn with approximately a **50° bank**.
    - Pilot performs another steep turn in the opposite direction, as specified by the instructor.
    - Pilot maintain the entry altitude ±100 feet, airspeed ±10 knots, bank ±5°, and roll out on the entry heading ±10°.