Flight Lesson: Steep Turns

Objectives:

1. Exhibit knowledge of the elements related to steep turns and spirals
2. Be able to perform the steep turn with minimal assistance from the instructor

Justification:

1. Develops smoothness, coordination, orientation, division of attention, and control techniques while an aircraft is near performance limits.
2. Steep turns are required for the Private Pilot checkride.[1]

Schedule:

Activity	Est. Time
Ground	0.5
Preflight/Taxi	0.25
Flight	1.25
Debrief	0.25
Total	2.25

Recommended Readings:

PHAK	Ch 3: 3-9 to 3-17 - Load Factors 3-26 to 3-31 - Design Char.
AFH	Ch 9: 9-1 to 9-3- Steep Turns

Elements Ground:

- Steep Turns
  - ➡ Overbanking Tendency
  - ➡ Load Factors
  - ➡ Stall Speeds
  - ➡ Shallow vs Steep Turns

Elements Air:

- Steep Turns (left and Right)

Completion Standards:

1. Exhibits knowledge of the elements related to steep turns
2. Correctly demonstrates steep turns in both directions within acceptable PTS standards.
3. Maintains proper division of attention between airplane control and orientation.

Common Errors:

- failure to adequately clear the area
- excessive pitch change during entry or recovery
- attempts to start recovery prematurely
- failure to stop the turn on a precise heading
- excessive rudder during recover, resulting in skidding
- inadequate power management
- inadequate airspeed control
- poor coordination
- gaining altitude in right turns and/or losing altitude in left turns
- failure to maintain constant bank angle
- attempting to perform the maneuver by instrument reference rather than visual reference
- failure to scan for other traffic

[1] *PP PTS; AoO: V.; Task Steep Turns;*

Presentation Ground:

Steep Turns

1. *Overview*

(1) ***Steep Turn*** : A turn in either direction using bank steep enough to cause overbanking tendency, during which maximum turning performance is attained and relatively high load factors are imposed.

(2) *Simply put, 45° banking turn to the left or right for 360°-720°.*

(3) PTS Standards:

PTS Standards			
initial altitude	selected altitude	**initial airspeed**	Va
Δ altitude	±100 ft	**Δ airspeed**	+0
initial heading	selected heading	**bank**	45°
rollout heading	±10° of initial	**Δ bank**	±5°

(4) object is to achieve a near-maximum performance turn; enough to cause overbanking tendencies, and impose relatively high load factor.

2. Shallow vs Steep banks

(1) The reason an airplane does not over bank during a shallow turn is due to the lateral stability of an airplane, but the plane sill creates a slight differential in each wing's lift.

(2) In a steeper bank, the differential in lift is great enough to overcome the lateral stability of the plane.

(3) So in short:

i. Shallow turns - hold aileron into turn (Δ lift < lateral stability)

ii. Medium turns - hold aileron neutral (Δ lift ≈ lateral stability)

iii. Steep turns - hold aileron opposite turn (Δ lift > lat stab.)

3.Overbanking Tendency

(1) *:after reaching a certain bank angle, the tendency for an airplane to roll farther into the banked turn.*

(2) As the radius of a turn becomes smaller. a significant difference develops between the speed of the inside wing, and the outside wing.

(3) The wing on the outside of the turn must travel a farther distance in the same amount of time as the inner wing.

(4) Thus the outer wing travels faster and creates slightly more lift than the inner wing, and the plane wants to continue rolling into the turn after the controls are neutralized.

(5) To correct overbanking, use a small amount of opposite aileron to maintain your desired angle of bank.

4. Load Factor

(1) *:the ratio of the load supported b the airplane's wings to the actual weight of the aircraft and its contents.*

(2) (Draw pictures of load factor in S&L vs. Steep Bank)

i. Load Factor = Centrifugal Force + Weight

ii. on the ground or in straight-and-level non-accelerating cruise flight load factor is one (1G)

iii. in a steep turn, load factor is 1G + the amount of centrifugal force acting on the aircraft.

(3) In a level turn, with a bank angle greater than 60°, load factor increases dramatically with an increase in bank.[2]

i. 60° = 2G; 70° = 3G, 80° = 6G

(4) Load Factor is important to us because aircrafts all have positive and negative load limits.

i. Most GA aircraft in normal category have a pos. load limit of 3.8G and neg. close to -1.5G

ii. Above these load limits, the aircraft is subject to structural damage. This is where our entry airspeed comes into play. By definition, Va is the speed at which any abrupt full control deflection would result in a stall *before* it results in exceeding the load limits of the aircraft.

iii. By entering at this speed, and never exceeding it, we can ensure no damage to the aircraft.

5. Adverse Yaw

(1) *:tendency for an airplane to yaw opposite the direction of roll when initiating a turn*

(2) when an airplane rolls into a turn, the wing the is being raised creates more lift that the wing being lowered.

(3) the raised wing *also* creates more drag.

(4) because of the uneven drag components on either side of the longitudinal axis, the airplane wants to yaw towards the raising wing.

i. to counteract adverse yaw, correct rudder pressure must be applied when initiating a turn.

(5) Turns to the right display more adverse yaw than turns to the left

i. because of the natural left turning tendencies our airplane exhibits, the adverse yaw is counteracted a bit more.

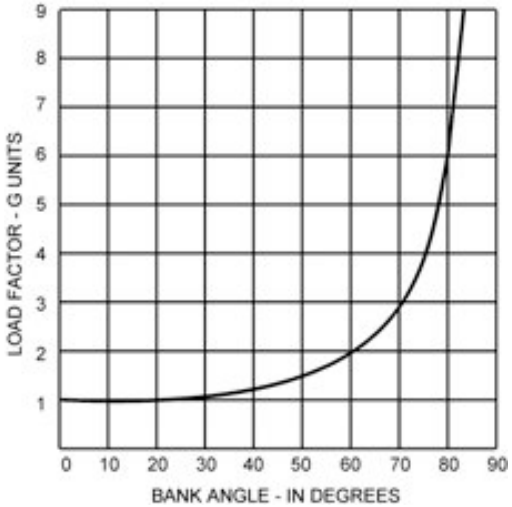
6. Stalling Speed[3]

(1) *:the speed at which the critical angle of attack is exceeded, causing loss of lift and a large increase in drag due to disruption of airflow.*

(2) as bank angle increases, a greater amount of lift is required to maintain level, and thus, the aircraft is closer to the critical AoA.

i. as load factor goes up, weight supported by the wing goes up, thus stall speed goes up.

(3) i.e., if maintaining altitude; stall speed, load factor, and angle of bank are positively related to each other (one goes up, the others go up as well)



7. Procedure

(1) select an altitude appropriate to steep turns (+1500 AGL)

(2) clear the area!

(3) establish Va. (In C152 and C172 it will already be established)

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[2] *image courtesy of: http://www.pilotsweb.com/principle/load.htm*

[3] *image courtesy of: http://www.aerospaceweb.org/question/performance/q0146.shtml*

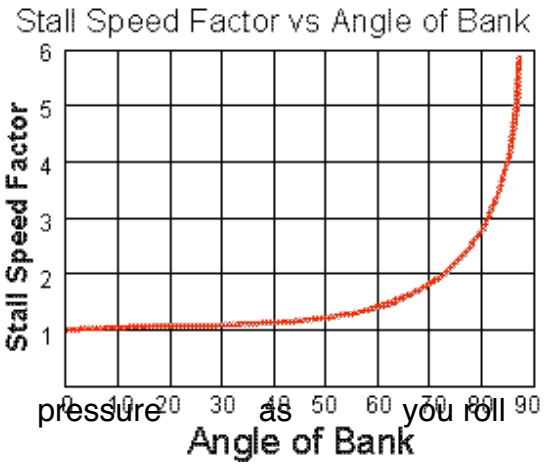
(4) pick a point on the horizon which will be your roll out point

i. also note heading and possibly set heading bug

(5) make a smooth roll into the turn, applying aileron and rudder gradually and simultaneously

(6) as bank increases, increase back pressure and apply power as necessary

(7) try to keep the *center* of the nose in the level attitude.



(8) continue bank to 45 degrees, then apply opposite aileron as necessary to keep the bank constant.

(9) LOOK OUTSIDE, this is a visual reference maneuver

(10) reference your attitude indicator, altimeter, and DG

(11) approximately 20 degrees before target heading, begin smooth rollout, using more opposite aileron and rudder, releasing back pressure as you roll out.

(12) continue straight and level flight.

(13) what will it look like?

i. difference between left and right turns

(14) what will it feel like?

i. roller coaster bottom turn?

8. Steep Spiral Dive

(1) An event that occurs when a steep turn is entered, but too little back pressure is applied.

(2) This causes the aircraft to descend

(3) The pilot then realizes the descent and applies more back pressure

(4) Most often, the pilot is now preoccupied with the back pressure, and the overbanking tendency continues to bank the aircraft.

(5) This leads to a steep and smaller radius descent.

9. Steep Spiral Recovery

(1) reduce power

(2) decrease bank angle

(3) increase pitch

Presentation Air:

1. Steep turns

(1) to the left

(2) to the right