MANEUVERS

FULFILLS PA.V, PA.VII, CA.V, CA.VII, AI.IV.A

Objective	
The student shall understand the motivation, theory, process, and key points to success for each maneuver outlined in this guide,. The student shall become familiar with performing these maneuvers in flight.	
Instructor Actions	**Student Actions**
- Present maneuvers utilizing model airplane - Demonstrate the maneuvers in-flight - Split the maneuver into chronological or skill-based segments - Evaluate students performance	- Take notes and participate in instructor's discussion - Explain maneuver process to instructor - Perform maneuvers in-flight - Chair fly maneuvers at home
Case Studies	**Equipment**
- None	- Model Airplane - POH - Training Airplane
Completion Standards	
The student shall repeatedly perform the maneuvers within ACS standards and understand the risks associated with each maneuver. The stall shall become familiar with executing the pre-maneuver checklist and establishing suitable and adequate reference points.	

ELEMENTS

RESOURCES

FAA-S-ACS-6C (Private Pilot ACS) - Area V and Area VII
FAA-S-ACS-7B (Commercial Pilot ACS) - Area V and Area VII
FAA-S-ACS-25 (CFI ACS) - Area IV Task A
FAA-S-8081-9D (CFII PTS) - N/A

FAA-H-8083-3C Airplane Flying Handbook

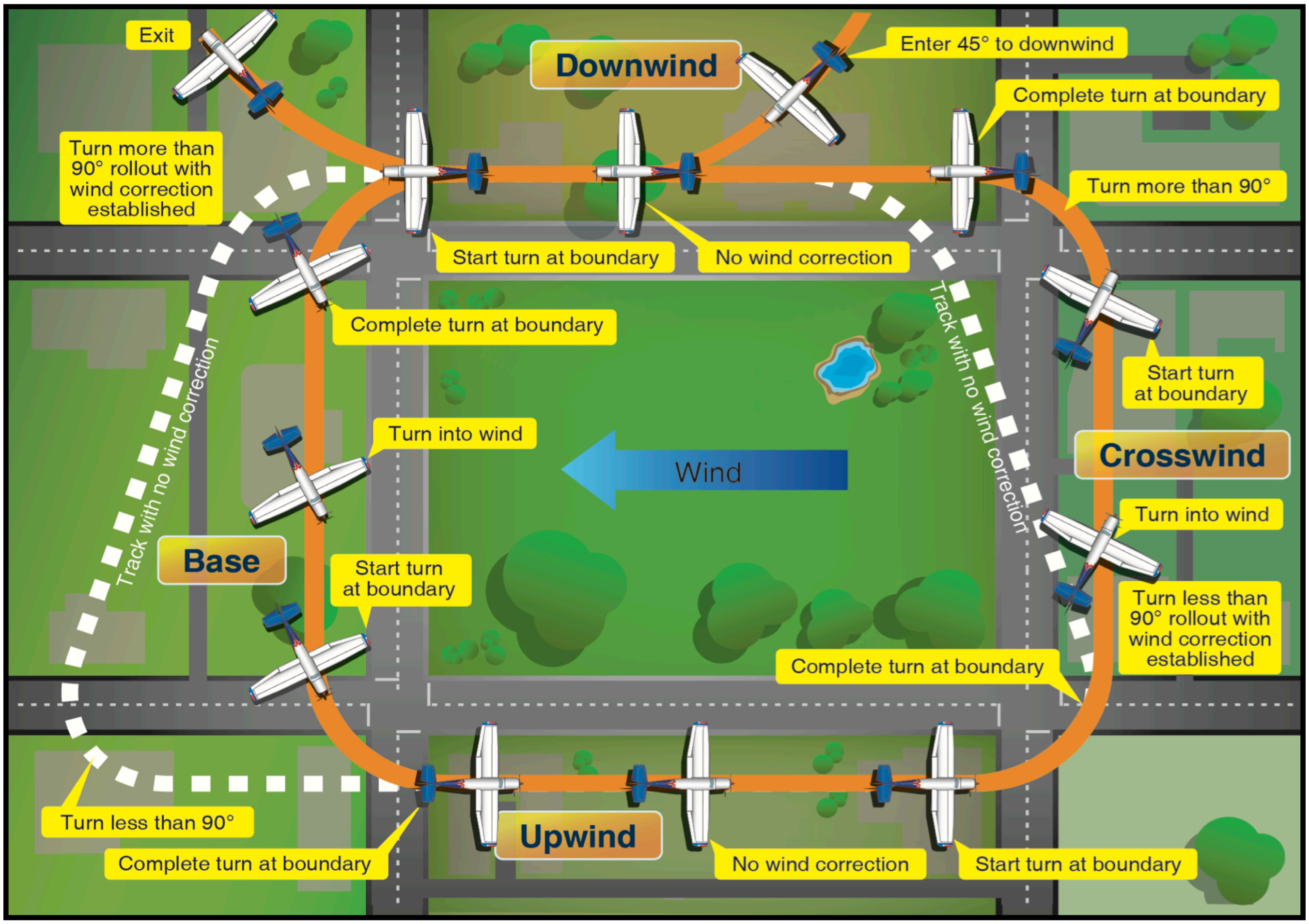
RECTANGULAR COURSE

AFH CHAPTER 7

Motivation
The most fundamental ground reference maneuver - the rectangular course - teaches pilots how to compensate for the effects of wind drift in a constant heading segment. Additionally, as the rectangular course emulates the traffic pattern (an integral part of *every* flight), mastery of the rectangular course assures proficiency in navigating around the traffic pattern!

A rectangular course in a zero-wind day is quite simple, just four perpendicular segments. However, there is almost always some amount of wind, especially here in the Antelope Valley. If we failed to correct for the wind, the course shown in white would be flown. However, we strive for the orange course. Remember, this is a ground reference maneuver, so roads work quite well.

It is helpful to consider beforehand which turns will be less than 90° and which will be more than 90°. That answer all depends on if we are upwind or downwind, as the crab direction is always into the wind.



Common Errors of Rectangular Course
1. Failure to maintain altitude
2. Failure to properly assess wind direction
3. Poor coordination

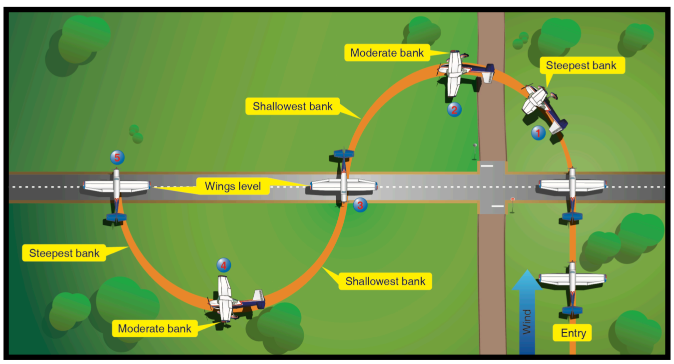
S-TURNS AND TURNS AROUND A POINT

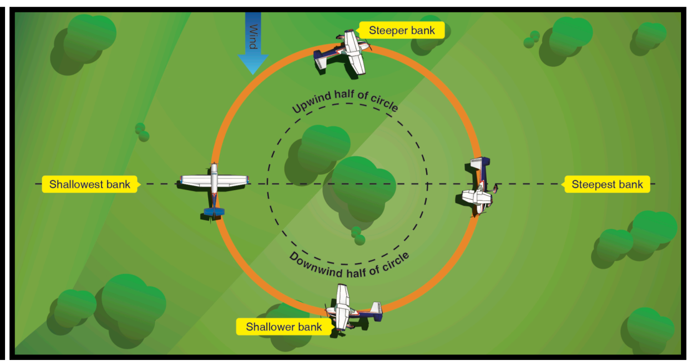
AFH CHAPTER 7

Motivation
Understanding the effects of wind drift are imperative throughout all phases of flight. The concepts of wind correction apply to more advanced ratings, although the ability to correct for wind drift should be developed significantly as a student pilot.

We’ve discussed drift control, but what about if our heading is continuously changing? Its easiest to think about the extremes - downwind we are fastest groundspeed, upwind we have slowest. Therefore, anything in between is changing between those two states. To keep a constant radius turn around a point, we will want to fly at the steepest bank with greatest groundspeed, and shallowest bank with least groundspeed. If the student is having issues performing the maneuver with reference to the center of the circle, try choosing points symmetrically spaced around the circle and bringing the airplane directly over those points.

The s-turn has a similar objective to turns around a point: that is to learn to account for wind drift. However, we perform this maneuver by timing our 180° turns to align the lateral axis with a ground based reference point, such as a long road.





Common Errors of S-Turns and Turns Around a Point
1. Failure to maintain altitude
2. Failure to properly assess wind direction
3. Failure to properly execute a constant-radius turn

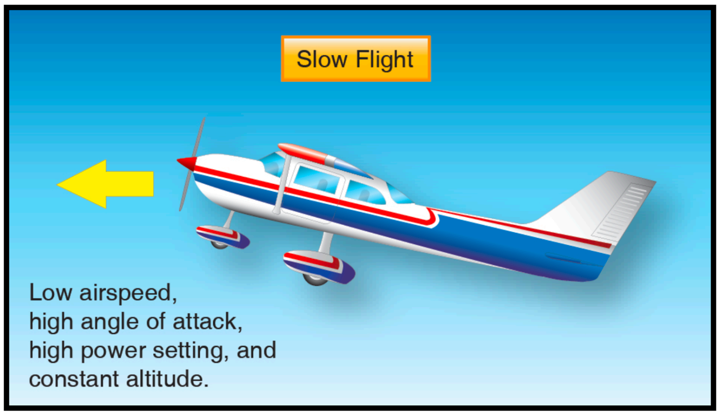
SLOW FLIGHT
AFH CHAPTER 5

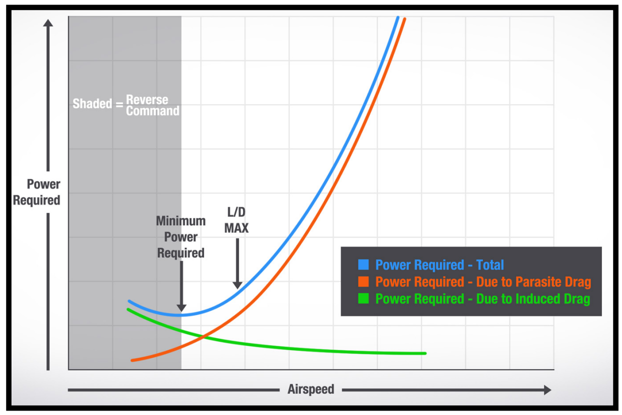
Motivation
Handling characteristics of the airplane are dependent on it’s airspeed. Slow flight is an important maneuver to demonstrate the low airspeed handling qualities of the airplane, observing the pitch/power relationship and control surface deflections required. By practicing slow flight, the pilot becomes familiar with the feel, sound, and visual cues at low airspeeds.

Introduce lift equation

The first thing we notice in slow flight is the significant power required. At cruise, total drag is dominated by parasitic drag with little induced drag. At slow speeds, induced drag is dominant because we must fly with a high angle of attack since our V is low.

We say we are flying on the “back-side of the power curve), because drag increases below the minimum power required velocity. In this region, **pitch controls airspeed, power controls altitude.**





Secondly, airflow over the control surfaces is reduced. As a result, more deflection is required to achieve the same response at higher airspeeds. We will notice the controls feel ‘mushy.’ We should avoid large bank angles since it is easy to enter an **accelerated stall.**

Lastly, we may periodically hear the stall warning horn. This is normal, but we want to minimize this and keep the airspeed tolerance on the positive side.

This maneuver may be performed in either the landing configuration or the clean configuration.

Common Errors of Slow Flight
1. Fixation on the flight instruments
2. Insufficient right rudder
3. Poor power managements

STALLS

AFH CHAPTER 5

Motivation

Our discussion of aerodynamics is incomplete without a demonstration of stalls. Let's move beyond the rote knowledge of definitions and see how the airplanes responds. Then, we can apply stall awareness to all future maneuvers and flights!

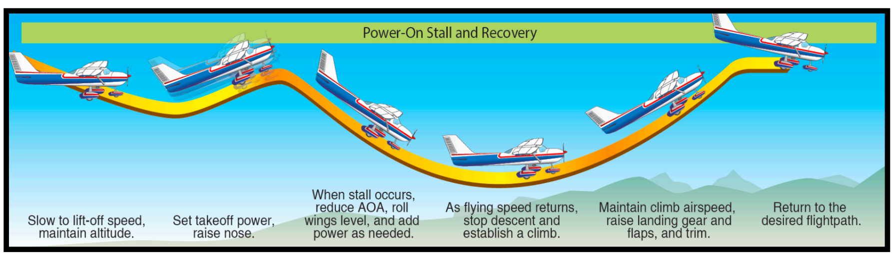
It is important to note that there is **NO** correlation between pitch attitude and angle of attack. Remember, a wing stalls at a constant angle of attack, which is the angle between the chord line (a function of wing design) and the relative wind (a function of airplane direction of motion). A fighter jet flying straight vertical has its chord line and its direction of motion vertical, meaning **0°** angle of attack.

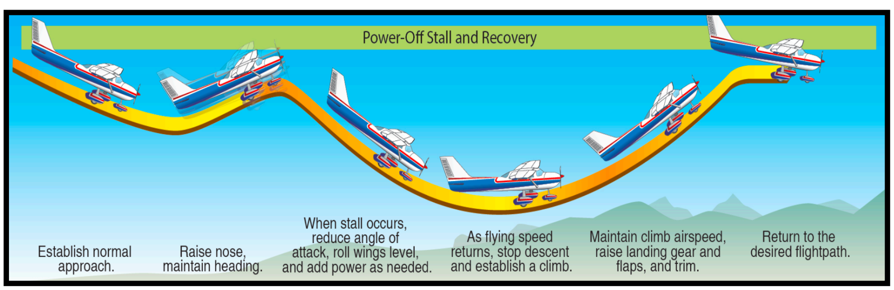
An airplane can stall with the nose **BELOW** the horizon. Consider an aerobatic pilot. The pilot is flying 45° nose low, and suddenly applies full aft elevator. The airplane rapidly pitches up. The pitch attitude has increased, but the direction of motion has not had time to change, so the angle of attack has increased significantly. Thus, the airplane can stall. See this video.

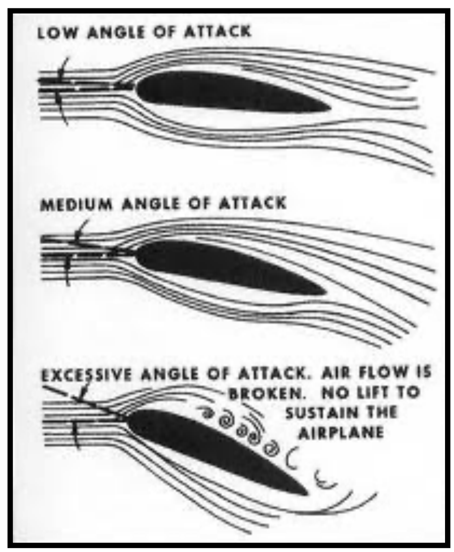
The two times pilots are close to stall are during takeoff and landing.

Common Errors

1. Fixating on or ignoring aircraft coordination
2. Correcting wing drop with aileron rather than rudder
3. Not recovering with a positive rate







STEEP TURNS

AFH CHAPTER 10

Motivation
Just as we expanded the envelope in slow flight, we will also expand the bank envelope with steep turns, as understanding how the airplane responds at these larger bank angles is imperative. Additionally, practicing steep turns allows us to develop our skills in flight control smoothness and coordination.

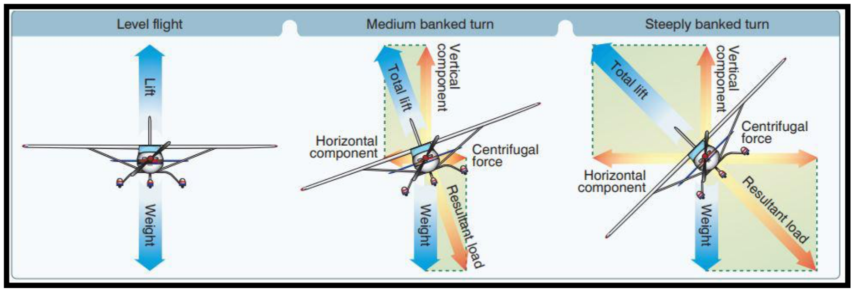
Were going to learn a lot about the airplane today. While our previous lessons have focused on the fundamentals of airplane control at the center of the attitude envelope, today we will see how the airplane handles at larger bank angles. The skills learned today will help you become familiar with higher g forces, a phenomenon we call "overbanking tendency", and emphasize the pitch control forces needed to sustain level flight. Lets discuss why these phenomena occur:

Simply entering the bank doesn't induce higher g forces. We will demo a highly slipped condition where we have this large bank angle but counter it with rudder to arrest any heading change. We will notice no increase in g. Turning is what provides the g force.

Accelerations are caused by a change in direction. In a turn, since we are continuously changing direction toward the inside of the turn, the acceleration acts inward. Imagine a car, where it feels like you are being flung outward. The tighter the turn radius and faster the airspeed, the greater the apparent g force.

Overbanking tendency is caused by 2 factors. First, the outer wing is traveling faster than the inner wing, since it is covering more distance in the same time. This induces more lift and thus more bank. Additionally, the airplanes inherent **directional** stability tries to yaw the airplane further into the turn.

The additional back pressure requires is due to the decrease in the vertical component of lift. As the airplane banks, the lift vector tilts with the airplane. We will need to add power as well. At the extreme end (90°), there is no more vertical component and flight cannot be sustained! The exception to this is of course aerobatic pilots, who can perform 'knife edge' flying.



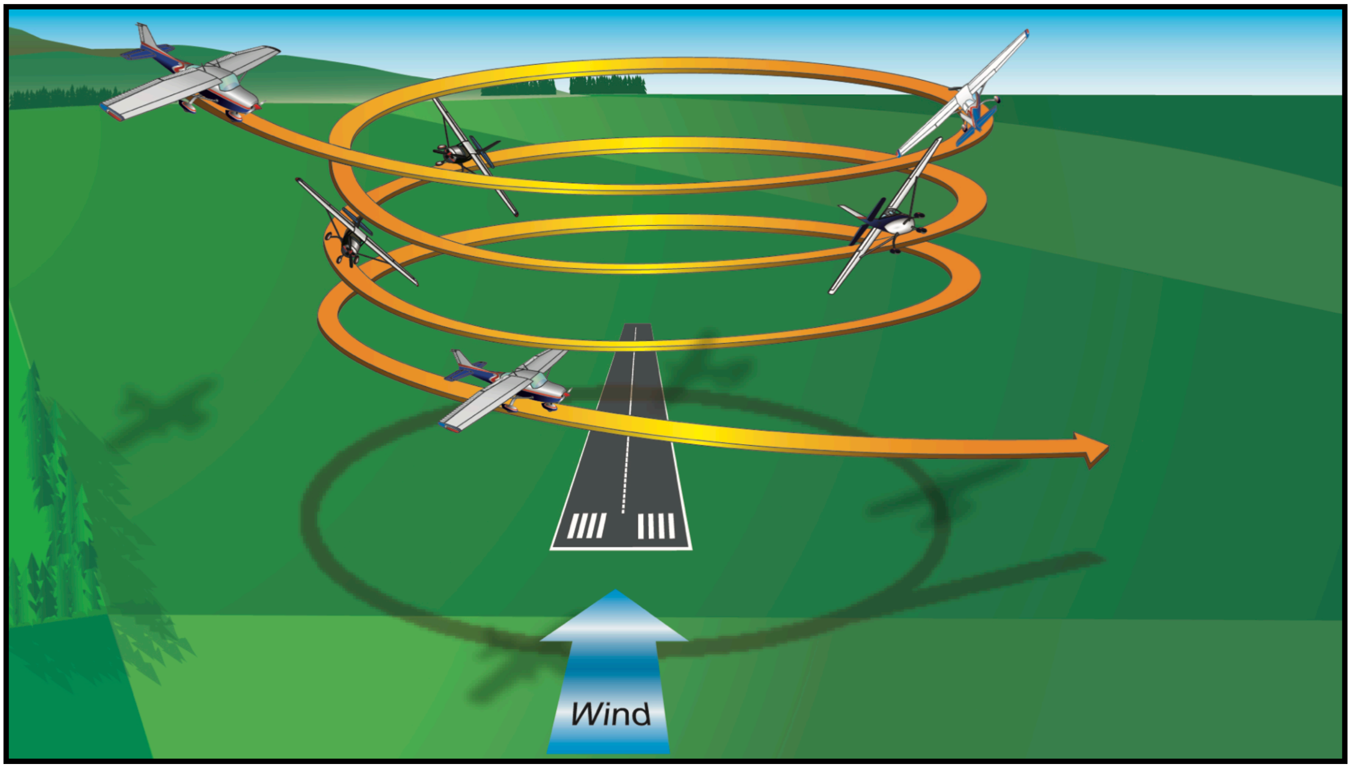
Common Errors of Steep Turns
1. Poor coordination
2. Not applying pitch control as needed to maintain altitude
3. Not understanding the sight picture, which allows for faster correction than referencing the attitude indicator

STEEP SPIRALS
AFH CHAPTER 10

Motivation
The objective of the steep spiral is to provide a flight maneuver for rapidly dissipating substantial amounts of altitude while remaining over a selected spot. If an engine fails and the best landing point is directly below you, it would only make sense to perform a spiraling turn to remain as close as possible!

The steep spiral combines the wind drift skills of turns around a point and the banking skills of steep turns. After best glide speed is established, bank angle is maximized, up to 60°, to decrease the vertical component of lift as much as possible.

When we perform this maneuver, we will ensure we complete three turns and finish above 1500 ft AGL.



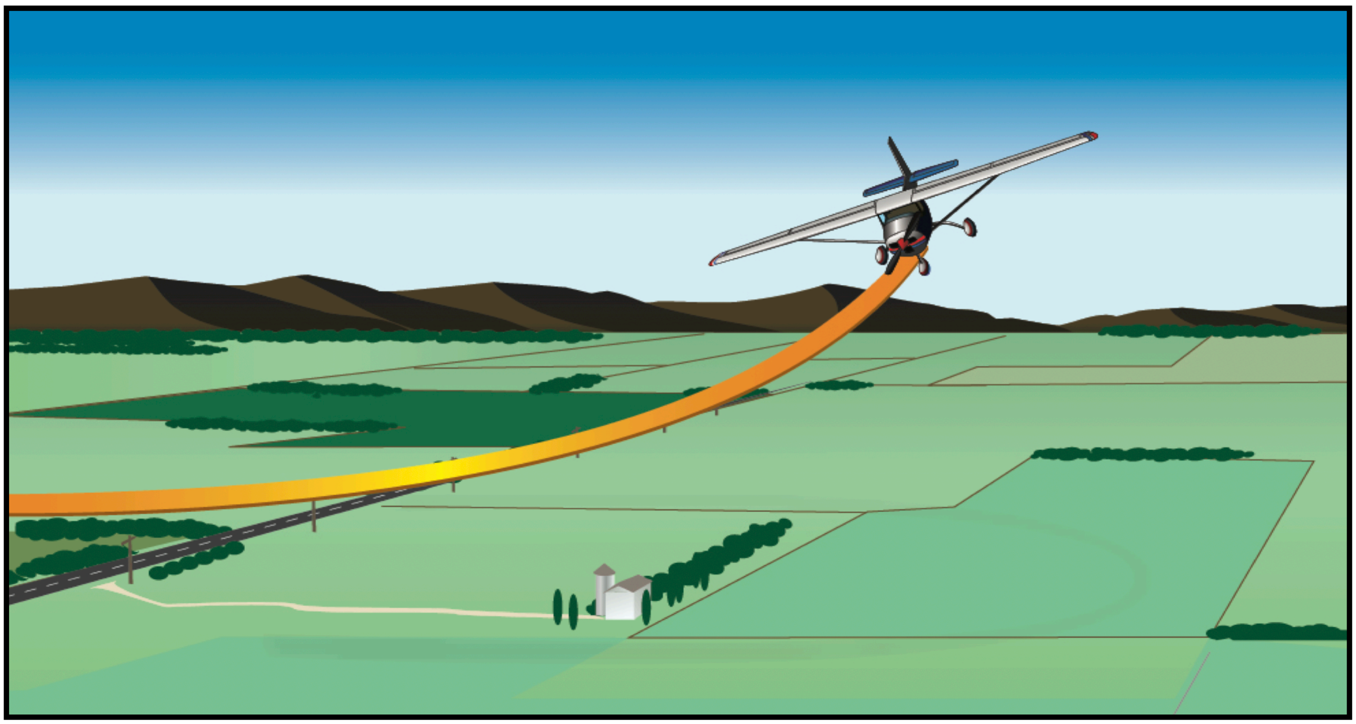
Common Errors of Steep Spirals
1. Ensuring coordination
2. Varying bank to prevent wind drift
3. Trim to hold that 70 KIAS

EMERGENCY DESCENT

AFH CHAPTER 18

Motivation
An emergency descent is a maneuver for descending as rapidly as possible to a lower altitude or to the ground for an emergency landing. The need for this maneuver may result from an uncontrollable fire, a sudden loss of cabin pressurization, or any other situation demanding an immediate and rapid descent. The objective is to descend the airplane as soon and as rapidly as possible while not exceeding any structural limitations of the airplane.

After reducing the throttle to idle, a 30°-45° turn should be established to decrease the vertical component of lift and improve traffic scanning. If the cause of the descent is an engine fire, Vne should be targeted. If the goal is due to a medical emergency or mechanical issue, vertical speed is preferred to airspeed. Flaps, landing gear, and a full-fine prop may help the pilot increase vertical speed further while keeping airspeed significantly below Vne (in our case, Vfe - 89 KIAS).



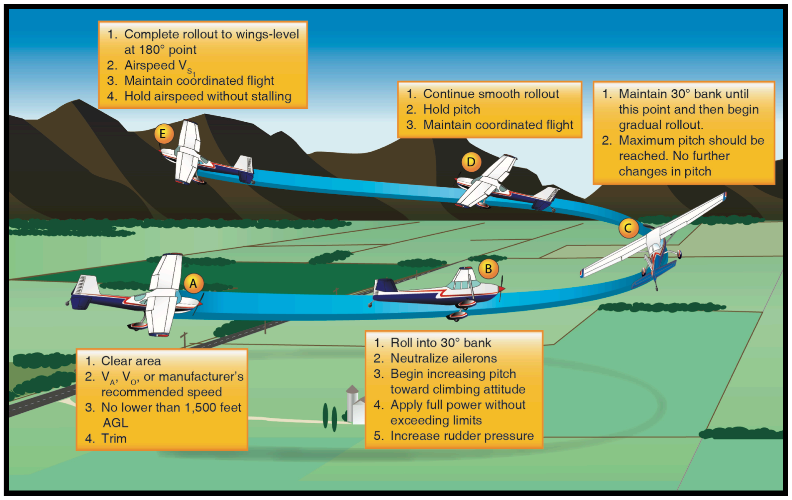
CHANDELLES

AFH CHAPTER 10

Motivation
Imagine departing Tehachapi airport. Tehachapi is nestled in a valley, with mountains on all sides. If the airplane is not performing as expected, it may be necessary to input evasive maneuvers to avoid CFIT.

A chandelle is a maximum performance, 180° climbing turn that begins from straight-and-level flight and concludes with the airplane in a wings-level, nose-high attitude just above stall speed. The goal is to gain the most altitude possible for a given bank angle and power setting.

A chandelle is best described in two specific phases: the first 90° of turn and the second 90° of turn. The first 90° of turn is described as constant bank and continuously increasing pitch; and the second 90° as constant pitch and continuously decreasing bank. During the first 90°, the pilot will set the bank angle, increase power, and increase pitch attitude at a rate such that maximum pitch-up occurs at the completion of the first 90°. The maximum pitch-up attitude achieved at the 90° mark is held for the remainder of the maneuver. If the pitch attitude is set too low, the airplane's airspeed will never decrease to just above stall speed. If the pitch attitude is set too high, the airplane may aerodynamically stall prior to completion of the maneuver. Starting at the 90° point, and while maintaining the pitch attitude set at the end of the first 90°, the pilot begins a slow and coordinated constant rate rollout so as to have the wings level when the airplane is at the 180° point. If the rate of rollout is too rapid or sluggish, the airplane either exceeds the 180° turn or does not complete the turn as the wings come level to the horizon.



Important things to note in the chandelle is the overbanking tendency, necessity for coordination, and accelerated stall awareness. In the Piper Tomahawk, expect about 300-500ft of altitude increase depending on the altitude. Additionally, the stall horn may become audible during the second half, however this is acceptable according to the ACS ("just above a stall airspeed").

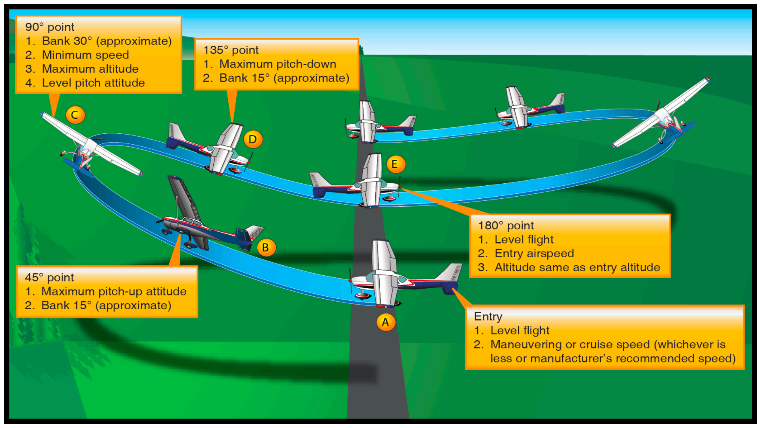
A good target for the middle point is ~10°-12° of pitch. Remember, in a coordinated 30° turn, stall speed increases from 52 KIAS to 56 KIAS (due to the increased load factor).

Common Errors of Chandelles
1. Incorrect bank at entry, we desire 30° – too little and premature stall. Too much and finish at high airspeed
2. Rolling wings level too soon or too late
3. Ensuring coordination

LAZY EIGHTS

AFH CHAPTER 10

Motivation
Impress your friends and examiner with your skillful piloting skills. The lazy eight is the culmination of the fundamental flight maneuvers and demonstrates mastery of the extensive theoretical phenomena - overbanking tendency, coordination, and right turning tendencies. Additionally, it is the only maneuver to require variable control input.



Lazy eights require constantly changing inputs. While they involve two 180° turns in opposite directions, the process is reversed. The pilot begins at a cruise power setting (2300 rpm), and says 'pitch pitch bank' to emphasize the relative magnitude of control inputs.

For the first 90°, the pilot should apply aft elevator, noting the slight increase in load factor. Crossing the 45° point, the pilot should relax the back pressure and feel the inflection change. Bank at the 45° point should be about 15°. Crossing through the 90° point, due to the 30° bank angle, the nose will appear to slice the horizon. Ensure that 30° is not exceeded – opposite aileron may be required to counteract the overbanking tendency. Also, be careful not to allow the nose to fall too soon. We need this altitude to compensate for the descend during the second half of the maneuver.

As the airplane continues past the 90° point in a nose down attitude, the pilot should be cognizant of the nose down attitude, and apply slight pressure to decrease the descent rate. Additionally, the pilot should begin slowly rolling out to wings level.

Common Errors of Lazy Eights
1. Too much altitude gain or loss. Do not be afraid to bring the nose up in the first 90°, as we will descend significantly in the second half
2. Too much bank. Fix with opposite aileron at 90° point
3. Poor coordination

EIGHTS ON PYLONS
AFH CHAPTER 7

Motivation
The eights on pylons are unmatched for developing intuitive control of the airplane. Rather than flying a constant radius circle by adjusting bank angle, we compensate for changes in groundspeed with changes in attitude, all while scanning for traffic.

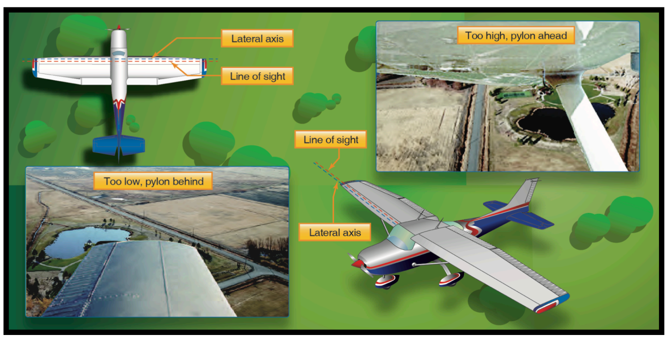
Eights on pylons are different from other ground reference maneuvers in that rather than adjusting bank to compensate for wind, we adjust altitude.

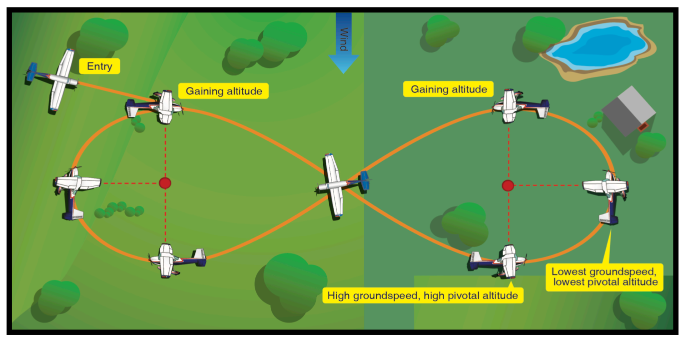
We leave power constant in this maneuver. After completing a wind circle, we determine our pivotal altitude from our highest groundspeed. Then, as we round the pylon, we should expect to descend as our groundspeed decreases (remember, we start downwind). We can pretend we are a dive bomber, if the reference point moves ahead of the wing we push forward and descend, if it moves behind we climb.

Pylons should be 1/2 mile apart. The reference point tells us what we need to do.

$$\text{Pivotal Altitude [ft]} = \frac{GS^2}{11.3} \text{ in knots}$$

GS [kt]	80	85	89	93	97	101
PA [ft]	566	639	701	765	833	903





Common Errors of Eights on Pylons
1. Not calculating pivotal altitude before starting
2. Asymmetrical turns
3. Poor coordination, do not attempt to cheat the alignment by adding rudder

SPINS AND SPIRALS

AFH CHAPTER 5

Motivation
Spin awareness is of upmost importance to pilots due to the significant altitude loss in recovery. Understanding why a spin occurs and the prerequisites for spins is crucial.

> A spin occurs when at least one of the airplane's wings exceed the critical AOA (stall) with a sideslip or yaw acting on the airplane at, or beyond, the actual stall. An airplane will yaw not only because of incorrect rudder application but because of adverse yaw created by aileron deflection; engine/prop effects, including p-factor, torque, spiraling slipstream, and gyroscopic precession; and wind shear, including wake turbulence. If the yaw had been created by the pilot because of incorrect rudder use, the pilot may not be aware that a critical AOA has been exceeded until the airplane yaws out of control toward the lowering wing. A stall that occurs while the airplane is in a slipping or skidding turn can result in a spin entry and rotation in the direction of rudder application, regardless of which wingtip is raised. If the pilot does not immediately initiate stall recovery, the airplane may enter a spin.

SPIN RECOVERY PROCEDURE

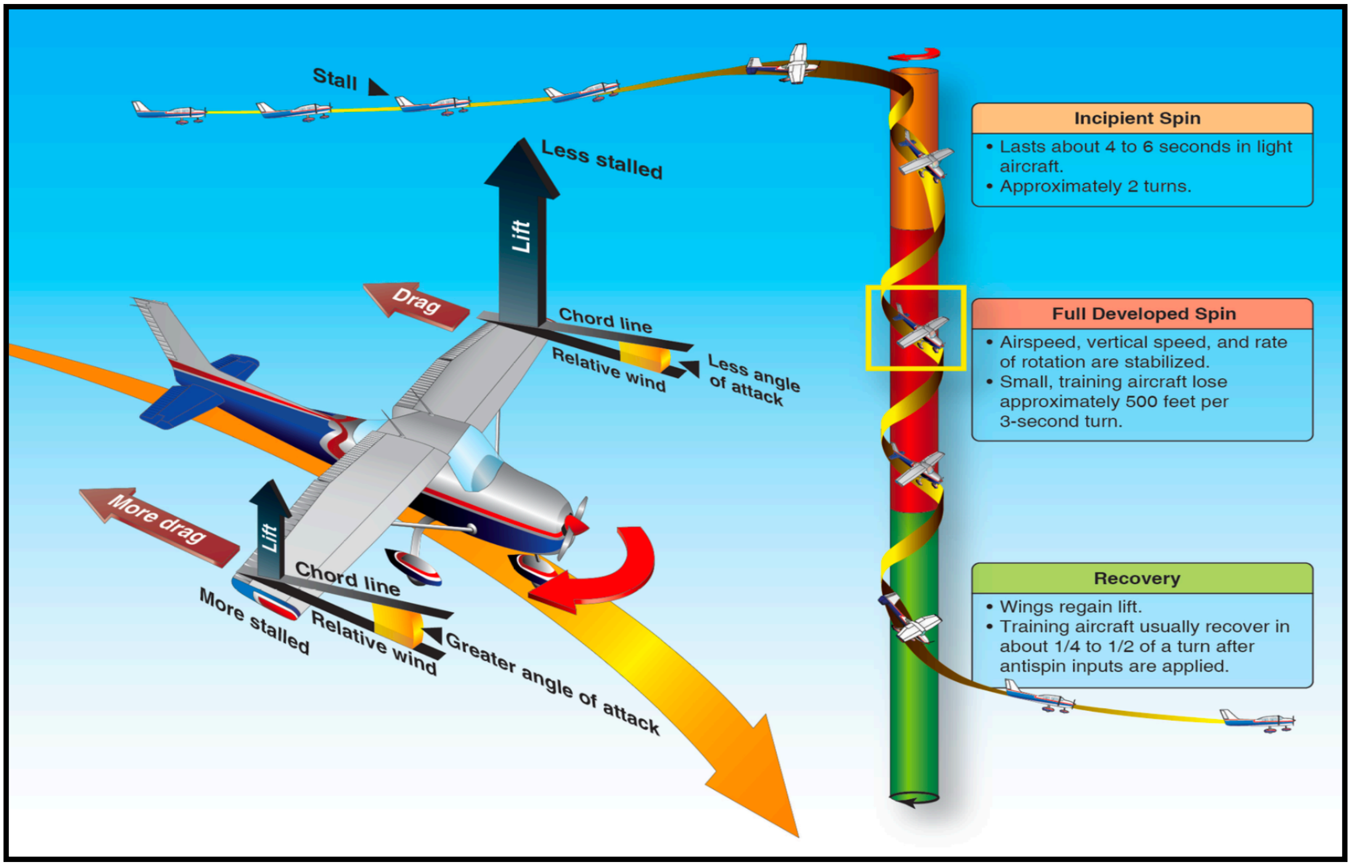
P	Power idle	To minimize gyroscopic effects
A	Ailerons neutral	Up aileron on low wing increases AOA, pushed further into stall
R	Rudder full opposite (reference turn coordinator)	Return coordinated flight
E	Elevator forward	To reduce angle of attack
	ONCE RECOVERED	
NEUTRALIZE rudder		
RECOVER with pull-up (~3g)		

A spiral looks nearly identical to a spin EXCEPT the airplane is rapidly increasing airspeed and is not stalled. A spin recovery would be sufficient to recover. Check airspeed to determine whether the airplane is in a spin or spiral.

Spin: 60-70 KIAS, oscillating
Spiral: 80+ KIAS, increasing

Other notes:

- Rudder blanking effects
- Pro spin aileron effects
- Check airspeed to ensure not in spiral



Common Errors of Intentional Spins
1. Failure to hold rudder in direction of spin
2. Failure to hold elevator full aft, resulting in a spiral
3. Failure to neutralize rudder after recovery, resulting in secondary spin in opposite direction

DEMONSTRATION OF FLIGHT CHARACTERISTICS AT VARIOUS CONFIGURATIONS AND AIRSPEEDS

Motivation
Demonstrated by a flight instructor, this maneuver demonstrates how the pitch/power settings change across the airplane's velocity envelope.

This maneuver can be performed in the clean or landing configuration.

CLEAN CONFIGURATION	LANDING CONFIGURATION
Establish level flight at Va	Establish level flight at Va
Slow to Vg, note pitch/power	Slow to Vfe, note pitch/power, deploy flaps to full
Slow to Vs1+1, note pitch/power and stall cues	Slow to Vref, note pitch/power
AT CONSTANT POWER, recover to level flight, note altitude loss	Slow to Vs1+1, note pitch/power and stall cues
	AT CONSTANT POWER, recover to level flight, note altitude loss