X.D. Eights on Pylons

References: Airplane Flying Handbook (FAA-H-8083-3)

Objectives	The student should develop knowledge of the elements behind the Eights on Pylons maneuver and have the ability to perform the maneuver to ACS/PTS standards.
Key Elements	1. Points moves forward: Forward Pressure 2. Point moves backward: Backward Pressure 3. Small, coordinated corrections
Elements	1. What is Pivotal Altitude? 2. The Basics 3. Calculating Pivotal Altitude 4. Performing Eights on Pylons
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 lesson is complete when the student understands Pivotal Altitude and the accompanying concepts to Eights on Pylons. The student also will have the ability to properly fly the maneuver.

Instructor Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

The eights on pylons maneuver started in WWI. This maneuver was developed in order to maintain a constant view of a target, allowing the gunner to destroy a target. A more practical application now, is keeping the wing out of the way for aerial photography.

Overview

Review Objectives and Elements/Key ideas

What

Eights on Pylons is an advanced maneuver in which the pilot's attention is directed at maintaining a pivotal position on a selected pylon, with minimum attention inside the cockpit.

The maneuver itself involves flying the airplane in a figure eight path around two selected points, or pylons, on the ground. However, no attempt is made to maintain a uniform distance from the pylon. Instead, the goal is to have an imaginary line that extends from the pilot's eyes to the pylon. This line must be imagined to always be parallel to the airplane's lateral axis. Along this line, the airplane appears to pivot as it turns around the pylon. In other words, if a taut string extended from the airplane to the pylon, the string would remain parallel to lateral axis as the airplane turned around the pylon. At no time should the string be at an angle to the lateral axis.

Why

The objective of this maneuver is to develop the ability to maneuver the airplane accurately while dividing one's attention between the flight path and the selected points on the ground. Eights on Pylons are extremely helpful in teaching, developing, and testing subconscious control of the airplane.

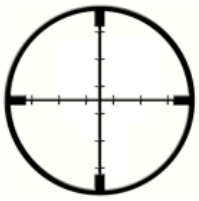
How:

1. What is Pivotal Altitude

A. General Description

i. A specific altitude at which, for a given groundspeed, the projection of the visual reference line to the pylon appears to pivot

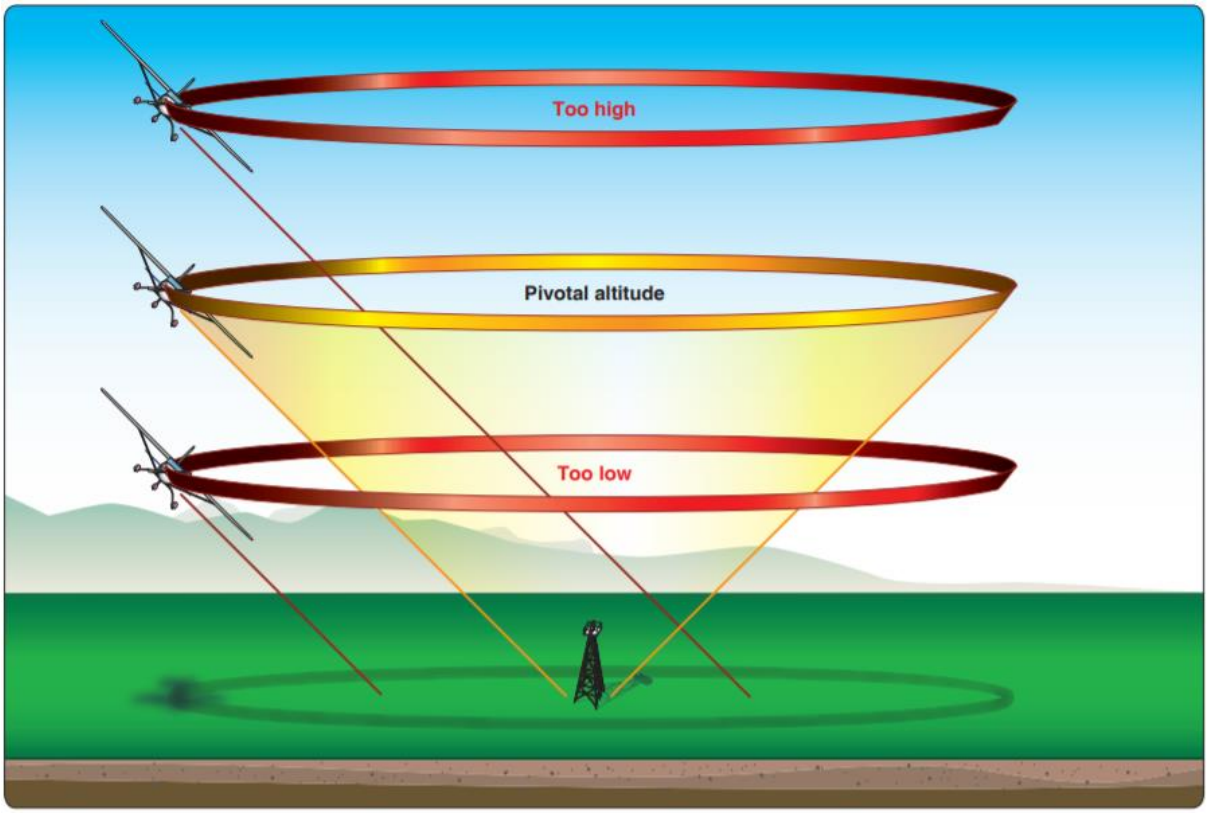
a. Basically, the pivotal altitude is the altitude which keeps the pylon in the same position on the window (or other aircraft reference, like the wingtip) as the aircraft turns around it



- The altitude varies with groundspeed
- The reference line is parallel with the lateral axis of the airplane
  - a *Off the wingtip in the case of the DA20
  - b In a swept wing aircraft, there will be no wing reference, so the point has to be kept in the same position on the window
    1. The same as keeping the pylon in the center of a target on the window

ii. When an aircraft is turning at the pivotal altitude, the wingtip appears to be fixed to a single point in the landscape, but when at any height other than the pivotal altitude, the wing tip will appear to move across the landscape

a. When an aircraft is turning at a height greater than the pivotal altitude, which is the normal situation in flight, the wingtip appears to move backward over the landscape
b. When an aircraft is turning at a height less than pivotal altitude (close to the ground) the wingtip appears to move forward over the landscape



2. The Basics

A. Pivotal Altitude is Based on Groundspeed
   i. As groundspeed increases, pivotal altitude increases, and as groundspeed decreases, pivotal altitude decreases
      a. The pivotal altitude does not change with bank
         - Distance from the pylon affects the angle of bank (more below)
   ii. Since the headings throughout the turns continually vary from directly downwind to directly upwind, the groundspeed will constantly change
      a. This will result in the pivotal altitude varying throughout the maneuver
         - To adjust for this, the pilot climbs or descends to compensate for the changing groundspeed and to maintain the visual reference with the pylon
         - The change in altitude will depend on how much the wind affects groundspeed
            a Strong winds create larger changes in altitude than light winds
            b No wind would result in no change in altitude

B. Maintaining the Pivotal Altitude References
   i. Pitch
      a. As groundspeed decreases, the pivotal altitude decreases
         - If no changes are made as the aircraft slows, we will be above the pivotal altitude
            a The wing will appear to move backward across the landscape (the point will move forward in relation to the wing)

- To compensate for the decreased groundspeed, the pilot must descend to maintain the reference line to the pylon
  - a When we descend, airspeed increases slightly, increasing pivotal altitude
    1. In effect, we descend to the lower pivotal altitude, and the pivotal altitude comes up to us
- General Rule: If the point moves FORWARD, apply FORWARD pressure

b. As groundspeed increases, the pivotal altitude increases as well
- If no changes are made as the aircraft accelerates, we will be below the pivotal altitude
  - a The wing will appear to move forward across the landscape (the point will move backward in relation to the wing)
- To compensate for the increased groundspeed, the pilot must climb to maintain the reference line to the pylon
  - a When we climb, airspeed decreases slightly, decreasing pivotal altitude
    1. In effect, we climb to the higher pivotal altitude, and the pivotal altitude comes down to us
- General Rule: If the point moves BACKWARD, apply BACK pressure

c. Corrections and Wind Speed
- Corrections are like tracking a VOR
  - a Once the correction is made (or an intercept angle is established), remove the correction when the pylon is back on the line of sight reference (Upon intercepting the radial)
    1. Don't make the correction and hold it
       a. That will result in going above/below the pivotal altitude
- Changes in pitch/altitude are based on the wind speed
  - a The greater the wind speed, the greater the variation in the maximum and minimum pivotal altitudes
- Too strong of winds becomes unsafe
  - a We get closer and closer to the ground
  - b Also, the airplane can be blown very close to the pylon, requiring very high bank angles

d. Common Error - Uncoordinated use of flight controls, and Application of rudder alone to maintain "line-of-sight" on the pylon
- This is the most common error in eights on pylons. Don't do it!
- Use altitude changes, rather than rudder pressure, to hold the reference point on the pylon
- Do not use the rudder to yaw the wing forward or backward to maintain the line-of-sight reference
- Cross controlled flight is extremely dangerous, especially close to the ground

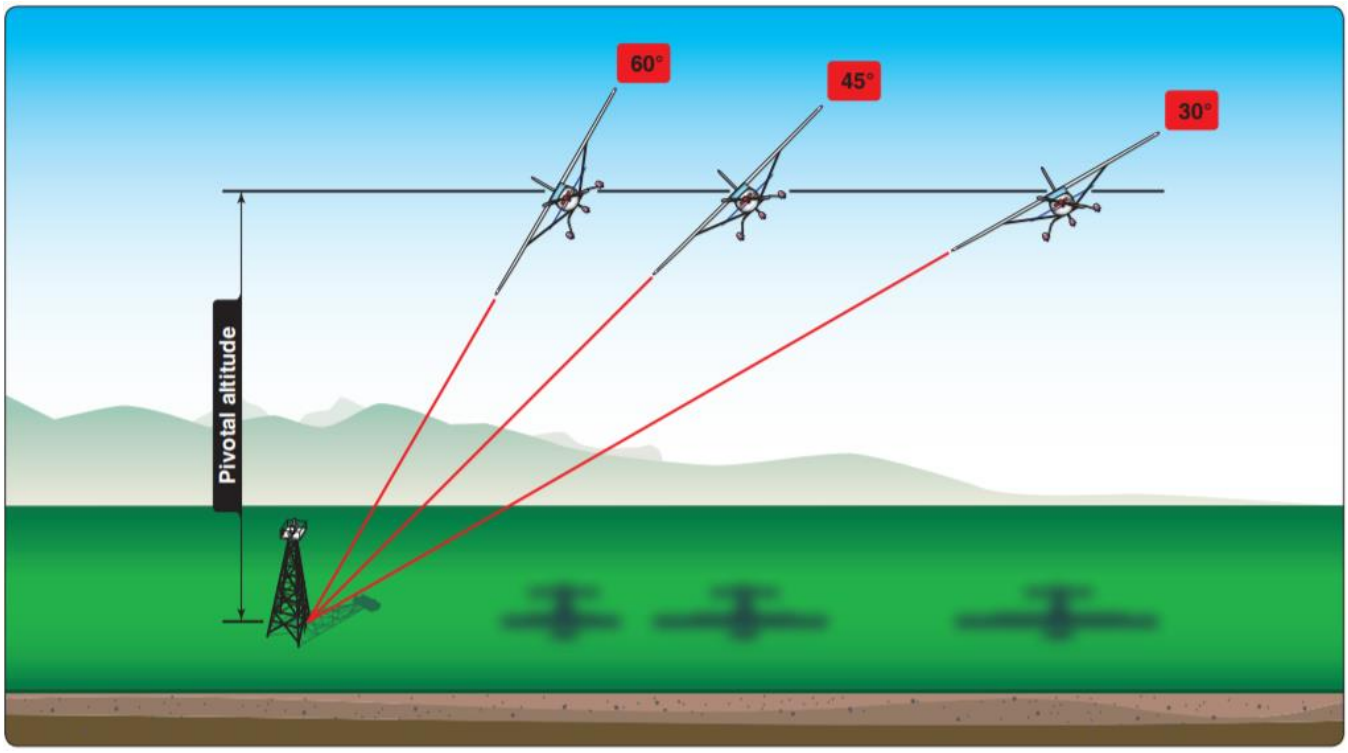
ii. Bank

a. Eights on pylons are performed at bank angles ranging from shallow to steep (no more than 40° per the ACS)
- The bank chosen does not alter the pivotal altitude

b. Distance from the pylon affects bank
- As wind pushes the aircraft toward or away from the pylons, bank will have to be adjusted to maintain the reference line

c. If the pylon moves above your reference point (i.e. above the wing tip), the aircraft is banked too steep, and bank will have to be decreased to maintain the line of sight reference
d. If the pylon moves below your reference point (i.e. below the wing tip), the aircraft is banked too shallow, and bank will have to be increased to maintain the line of sight reference
e. Note: Per the Airplane Flying Handbook, as proficiency is gained, the instructor should increase the complexity of the maneuver by directing the student to enter at a distance from the pylon that requires a specific bank angle at the steepest point in the pylon turn

iii. Common Error - Use of an improper "line-of-sight" reference
a. *In the case of the DA20 (and most non-swept, low wing aircraft) place the wingtip on the reference point and make adjustments to keep it there



3. Calculating Pivotal Altitude

A. Equation to estimate pivotal altitude
i. For Knots – $(Groundspeed^2 \div 11.3)$ + MSL
ii. For MPH – $(Groundspeed^2 \div 15)$ + MSL
B. Never going to be exact – use the planned true airspeed and estimated winds at altitude
C. Calculate the highest pivotal altitude: TAS + tailwind (highest groundspeed)
i. Use a flight computer
a. Take into account wind direction, speed, and true airspeed to get groundspeed
D. Calculate the lowest pivotal altitude: TAS – headwind (lowest groundspeed)

i. Remember that when in a headwind, we will be descending
   a. Groundspeed will be slightly faster than expected (since we're not level in the headwind), therefore, if the wind estimates are correct, we won't get as low as expected

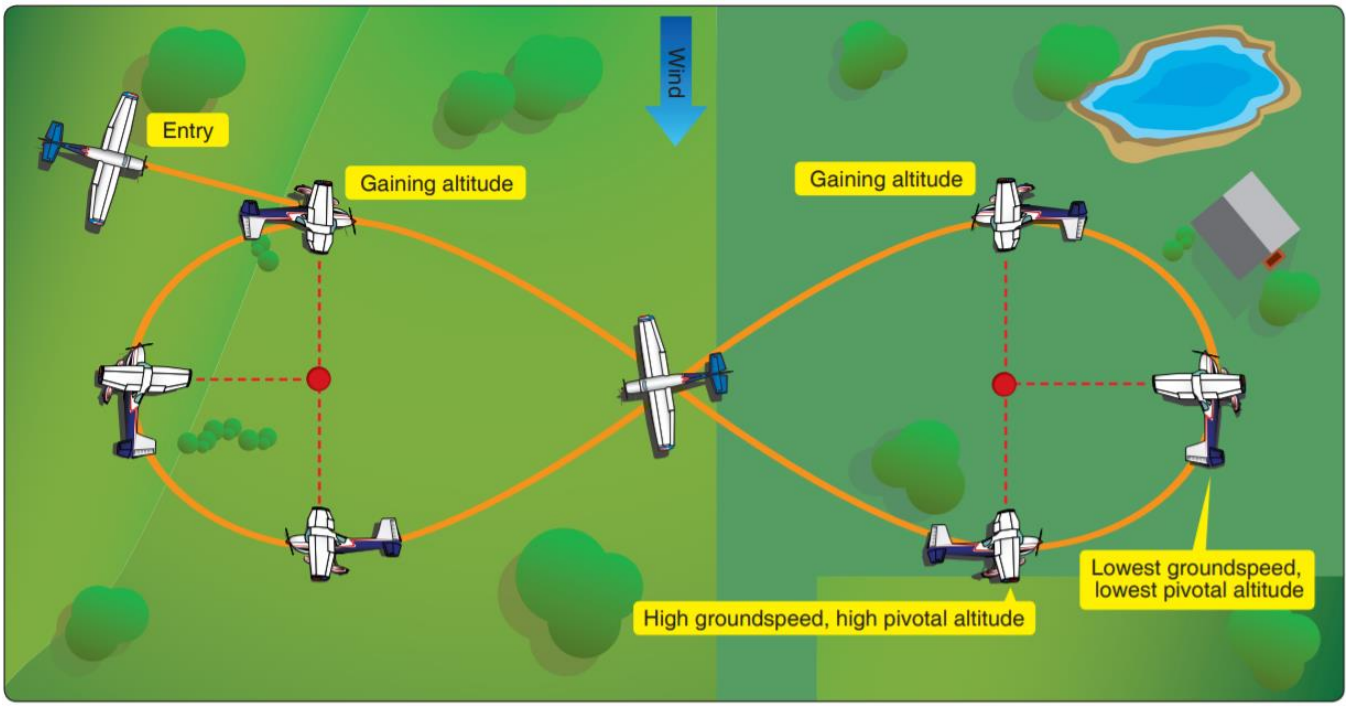
E. Calculating the highest and lowest pivotal altitude will provide an expected window during the maneuver
   i. If the altitudes are not safe, do not perform the maneuver

Groundspeed		Approximate Pivotal Altitude
Knots	MPH	
87	100	670
91	105	735
96	110	810
100	115	885
104	120	960
109	125	1050
113	130	1130

4. Performing Eights on Pylons

A. Selecting the Pylons
   i. Select two points on the ground along a line which lies perpendicular to the wind
      a. The pylons should be
         - Sufficiently prominent so the pilot can view them when completing the turn around one pylon and heading for the next
         - Adequately spaced to provide time for planning the turns but not spaced so far apart that they cause unnecessary straight-and-level flight between the pylons
            a The distance between the pylons should allow for the straight-and-level flight segment to last from 3-5 seconds
            b About ½ mile apart is a good estimate
               1. The length of a small runway
         - At the same elevation, since differences over a few feet necessitate climbing or descending between each turn
         - In an open area and are not near hills or obstructions
         - The smaller the pylon, the easier to notice changes in movement (as long as you can see it)
   ii. Common Error - Selection of pylons where there is no suitable emergency landing area within gliding distance
      a. Always be prepared for any type of emergency

b. When preparing for the maneuver, select the reference pylons as well as an emergency landing area



B. Before the Maneuver
   i. Pre-maneuver checklist
   ii. Ensure the area is clear of traffic
      a. Below, at, and above your altitude
   iii. The airplane should be trimmed for straight and level flight, at or below V_A
C. Entering the Maneuver
   i. Enter at a 45° angle to the downwind in order to make the first turn to the left around the left pylon
      a. The left turn puts the pylon out the left window (easiest to see), rather than looking over the right seat passenger and through the right window
      b. Make note of the entry heading as it will be the exit heading as well (bug the heading)
   ii. Fly to the midpoint between the pylons
   iii. On a downwind entry, the maneuver will start with the highest groundspeed and therefore at the highest pivotal altitude
   iv. Maintain straight and level flight until the pylon is just ahead of the reference line, then roll into a 30° to 40° bank
      a. Not to exceed 40°
   v. Place wingtip at the base of the pylon
   vi. Common Error - Faulty entry procedure, and Improper planning for turn entries and rollouts
      a. Plan ahead, orient yourself with the wind and enter at 45° to the downwind
      b. Preflight planning will get the aircraft as close as possible to the pivotal altitude. Although not perfect, only small adjustments should be necessary
D. First Turn
   i. Entry is at the highest groundspeed
      a. Continuing through the turn, into an increasing headwind, groundspeed will get progressively slower

- The pivotal altitude will decrease
  a. If no corrections are made, the pylon will move forward of the wing tip
     1. Forward movement = forward pressure

b. Descend to maintain correct pivotal altitude/reference point
- Do not wait for the pylon to get significantly out of position, make consistent small corrections
- Any airspeed gained in the descent increases pivotal altitude and helps to correct the visual reference

ii. Continuing the turn
a. As the aircraft continues around the turn, groundspeed will begin to increase, and therefore pivotal altitude will increase
- Climb in order to maintain pivotal altitude and maintain/correct the visual reference
  a. If no corrections are made the pylon will move backward in relation to the wingtip
     1. Backward movement = back pressure
  b. Any airspeed lost in the climb decreases pivotal altitude and helps to correct the visual reference

b. The relative wind will push the airplane towards the pylon
- Bank angle will increase in order to maintain the visual reference
  a. Remember, bank angle has no effect on pivotal altitude
  b. Since this maneuver does not require the turn to be completed at a constant radius, the pilot does not need to apply drift correction to complete the turn

E. Transitioning between Pylons
i. As the airplane turns toward a downwind heading, the rollout of the turn should be started
   a. The airplane should proceed diagonally to a point on the downwind side of the 2nd pylon
ii. Maintain straight and level flight for 3 to 5 seconds
iii. Crab into the wind to correct for wind drift
iv. Initiate a turn in the opposite direction when the pylon is aligned with the wing reference point
v. Common Error - Improper planning for turn entries and rollouts
   a. Plan ahead. Look ahead of the aircraft's position to anticipate what comes next
      - Smooth, proactive control inputs throughout the maneuver provide the pilot a much greater ability to think and plan ahead
   b. Know the entry and exit headings
vi. Common Error - Improper correction for wind drift between pylons
   a. The nose of the aircraft will have to point into the wind to properly correct for drift
   b. Maintain situational awareness of the aircraft in relation to the wind
      - This should be occurring throughout the maneuver, so the transition between the pylons should be no different
      - The stronger the wind, the greater the correction required

F. Second Turn
i. Entry is once again at the highest groundspeed, and therefore the highest pivotal altitude
   a. As the turn continues, groundspeed decreases as the aircraft experiences more of a headwind
      - Pivotal altitude decreases
        a. Descend to correct for changing groundspeed
        b. The pylon will begin moving in front of the wingtip

1. Forward movement = forward pressure

ii. As the aircraft continues around the turn, the headwind will transition into more of a tailwind, resulting in increased groundspeed
   a. Increasing groundspeed = Increasing pivotal altitude
   b. The pylon will move backward in relation to the wingtip
      - Backward movement = back pressure (climb)
        a Any airspeed lost in the climb reduces groundspeed and lowers the pivotal altitude
   c. At this point, relative wind also pushes the airplane closer to the pylon
      - Bank must increase to maintain visual reference

G. Exit
   i. After completing one rotation around each pylon, roll wings level, and exit on the entry heading

H. Common Error - Poor planning, orientation, and division of attention
   i. The entire maneuver is based on planning ahead (pivotal altitude), orienting yourself in relation to the wind and dividing attention between the aircraft, the reference points and what is coming next
   ii. Solid planning, starting with the pivotal altitude calculations on the ground, wind direction and reference point selection in the air, and smooth, proactive control inputs during the maneuver will make the eights on pylons much easier to perform
      a. Poor planning results in a sloppy, considerably more difficult maneuver

Common Errors:
- Faulty entry procedure
- Poor planning, orientation, and division of attention
- Uncoordinated use of flight controls
- Use of an improper “line-of-sight” reference
- Application of rudder alone to maintain “line-of-sight” on the pylon
- Improper planning for turn entries and rollouts
- Improper correction for wind drift between pylons
- Selection of pylons where there is no suitable emergency landing area within gliding distance

Conclusion:
Brief review of the main points
If the point moves forward, apply forward pressure
If the point moves backward, apply back pressure
Eights on Pylons is the most advanced and most difficult of the low altitude flight training maneuvers. Because of the various techniques involved, this maneuver is unsurpassed for teaching, developing, and testing subconscious control of the airplane.

PTS Requirements:
To determine that the applicant:
1. Exhibits instructional knowledge of the elements of eights on pylons by describing:
   a. The purpose of eights on pylons and their relationship to basic/advanced airmanship skills.
   b. How to determine the approximate pivotal altitude.
   c. How to select suitable pylons with consideration given to emergency landing areas.

   d. Orientation, division of attention, and planning.
   e. Configuration and airspeed prior to entry.
   f. Relationship of groundspeed change to the performance of the maneuver.
   g. Pilot's "line-of-sight" reference to the pylon.
   h. Entry procedure.
   i. Procedure for maintaining "line-of-sight" on the pylon.
   j. Proper planning for turn entries and rollouts.
   k. How to correct for wind drift between pylons.
   l. Coordination of flight controls.
2. Exhibits instructional knowledge of common errors related to eights on pylons by describing:
   a. Faulty entry procedure
   b. Poor planning, orientation, and division of attention.
   c. Uncoordinated use of flight controls.
   d. Use of an improper "line-of-sight" reference.
   e. Application of rudder alone to maintain "line-of-sight" on the pylon.
   f. Improper planning for turn entries and rollouts.
   g. Improper correction for wind drift between pylons.
   h. Selection of pylons where there is no suitable emergency landing area within gliding distance.
3. Demonstrates and simultaneously explains eights on pylons from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to eights on pylons.

Commercial Pilot ACS Skills Standards

1. Clear the area.
2. Determine the approximate pivotal altitude.
3. Select suitable pylons that will permit straight-and-level flight between the pylons.
4. Enter the maneuver in the correct direction and position using an appropriate altitude and airspeed.
5. Establish the correct bank angle for the conditions, not to exceed 40°.
6. Apply smooth and continuous corrections so that the line-of-sight reference line remains on the pylon.
7. Divide attention between accurate, coordinated airplane control and outside visual references.
8. Maintain pylon position using appropriate pivotal altitude, avoiding slips and skids.