CFI Bootcamp
Pilot Training

Power Hour Lessons

History of Selected Commercial Maneuvers using Previous and Current FAA Handbooks

- What did we lose over the years?

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Overview

1. **Three maneuvers explored:**
   a. Steep Spirals
   b. Chandelles
   c. Lazy Eights
2. **Handbooks used:**
   a. AC 61-21 - Flight Training Handbook 1965 - Federal Aviation Agency.
   b. AC 61.21a - Flight Training Handbook 1980 - Federal Aviation Administration.
   c. FAA-H-8083-3a - Airplane Flying Handbook 2004 - Federal Aviation Administration.
   d. FAA-H-8083-3b - Airplane Flying Handbook 2016 - Federal Aviation Administration.
   e. FAA-H-8083-3c - Airplane Flying Handbook -2021- Federal Aviation Administration.
3. **Steep Spiral** - In the earliest handbooks, they were performed with more than ten turns to teach vertigo avoidance. Once that was established, a ground reference was introduced for the pilot to maintain a fixed distance by varying the bank angle up to 60°. The speed used was between 1.3 and 1.4 Vso to teach accelerated stall awareness and to gain proficiency close to the stall speed. The maneuver was entered upwind, unlike all other ground reference maneuvers, so that upon completion of a number of turns, the airplane would be aligned with the landing runway. A modified pattern could be entered if the airplane was too high. This maneuver is called a performance maneuver but contains a ground reference component.
4. **Chandelle** - Candle in French. This was an aggressive high G maneuver developed in WWI to gain altitude and change direction. It was primarily used during dog fighting training and combat. The maneuver started by a 2-3 G pull almost to the vertical, and the airplane was turned 180° before a stall occurred. This had the look of a candle flame. The Chandelle is still in the Utility category in C172N models.
5. **Lazy Eigh**t - Probably developed during WWI. A maneuver was needed to quickly gain altitude and descend to avoid fire. It was initially done at 60 degrees of bank and now is performed at approximately 30 degrees. This maneuver is more difficult to do at lower bank angles.
6. The attached PDF has the maneuvers history from 1965 to the present. We will explore how the maneuver was taught through each of these handbook versions and we will see some things that didn't make it into the current version that are important. Particularly:
   a. Steep Spiral - The pitch attitude must be lowered as the bank increases in a steep spiral to maintain airspeed. The attitude must be increased with shallower banks. (Induced Drag.)
   b. There is load factor during the gliding turn because the airspeed is held constant.
   c. The maneuver is entered upwind. This is one of the few places, the 1965 handbook, that shows clear artwork of the entry and the reason for that.

d. Chandelles - Adverse yaw requires the pilot to ease up the rudder during a roll-out of a chandelle to the right (Left turning tendencies and Adverse yaw tend to cancel each other.) More right rudder is needed when rolling out from a chandelle to the left as adverse yaw is in the same direction as the Left turning tendencies.
e. The airspeed continuously decreases throughout the maneuver.
f. TIP: There will be an airspeed at the 90° point that will help you adjust the pitch attitude.
g. Lazy Eights - Selection of 45, 90, and 135 points should be on the horizon.
h. Airspeed is slowest at the 90° point, requiring the most rudder, especially in a turn to the right.

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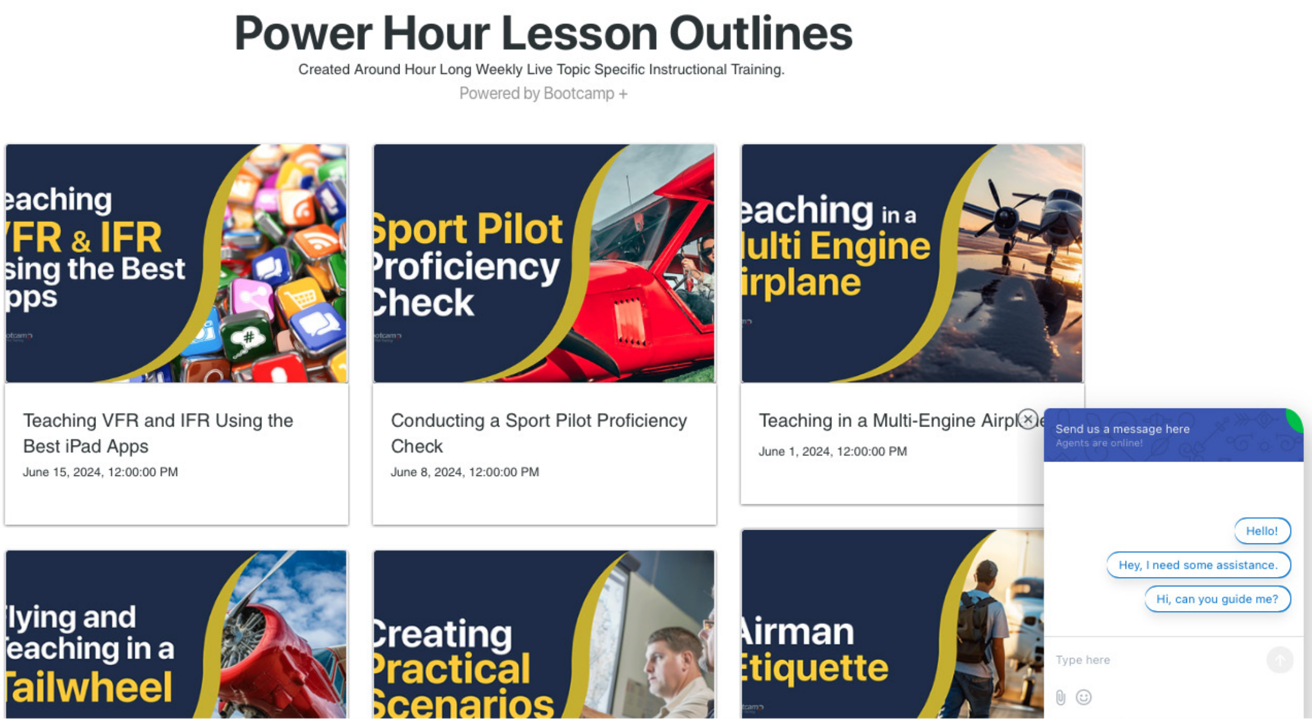

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EA-AC 61-21

FLIGHT TRAINING HANDBOOK

1965

FEDERAL AVIATION AGENCY

In the execution of steep turns, the degree of bank is decided upon before starting the series, and this degree of bank is maintained during each turn and also throughout the series. It should be exactly the same in both left and right turns.

The bank and the turn should begin simultaneously and with the proper amount of turn for the degree of bank from the time entry is started until the bank is complete, after which the proper ratio is maintained until recovery is started. The degree of bank is to be maintained until the rollout for recovery begins. The recovery requires much more application of rudder pressure than was necessary during the entry to insure that the airplane recovers cleanly on the heading desired without slip or skid.

In airplanes with fixed-pitch propellers, as the bank is established, throttle should be gradually increased as necessary. This increased power will aid in maintaining r.p.m. and airspeed, which will help to provide the additional lift necessary for flight in a banked attitude. During the rollout to level flight, throttle should be reduced as necessary to prevent the r.p.m. from becoming excessive. In airplanes with constant-speed propellers, the power may be left at cruising power throughout the maneuver.

The most common faults are: Too much pitch change during entry or recovery; roughness on the controls; attempts to start recovery or to sneak out of the bank before the recovery point is reached; failure to time the beginning of the roll out and the rate of roll out to recover exactly on the desired heading; too much rudder during recovery, causing skidding after recovery and requiring adjustment before straight-and-level flight can be resumed; inability to execute exactly the same degree of bank in right- and left-hand turns; inability to hold a constant degree of bank during the turn.

When proficiency has been developed and excellent recovery technique habitually demonstrated, the bank should be reversed without the intermediate straight flight by rolling from one bank to exactly the same degree on the other side. This should be accomplished slowly and smoothly. If rapid reversal is permitted, roughness and poor coordination will develop. Only by slow, smooth pressures can the student develop his feel of the controls and analyze his errors of coordination.

The same steps are used in the execution of this rolling from one bank to the other as in the intermediate stage of straight flight.

The recovery from the turn is timed so that as the wings pass through level flight the airplane is on the proper heading, and then the turn should start in the opposite direction as soon as the bank starts. Although it should both appear and feel to be one smooth maneuver, the same steps of control action are there except for the control adjustment to maintain level flight.

When proficiency in steep precision turns is attained, practice should begin in 720° steep power turns, first returning to level flight at the completion of each turn, and then rolling directly from one to the other. Although the principles required for the execution of these is the same as for other steep turns, they will be found to give the student a more advanced conception of coordination, orientation, and power control. These turns should be performed with banks from 45° to the limit of the airplane's performance. Either the amount of power available or the stress limits of the airplane will limit the steepest bank performed.

These 720° power turns should evidence a high degree of proficiency, since they are an excellent safety exercise in power and speed control for possible future turns near the ground. They are a requirement on commercial pilot flight tests.

Steep Spirals

A tight spiral is nothing more than a continuous steep bank in a gilde. It is a valuable flight training maneuver, and has practical application in providing a procedure for landing approaches from higher than normal traffic pattern altitudes, especially for emergency landings.

It is excellent in improving all power-off turns, teaching orientation under difficult circumstances, and revealing any possible tendency in the student toward vertigo. Such a tendency can be eliminated by building up an immunity to it through the practice of this maneuver, if the practice is not too prolonged at any one time. It has one other excellent feature too often overlooked—that of teaching normal recovery from steep gliding turns and eliminating any tendency in the student to stall or dive out of a steep gliding turn.

Plenty of altitude must be obtained before starting this maneuver in order that the spiral may be continued through a long series of turns, since it will be found that the student will probably exhibit no difficulty in the first two or three turns. It is only when it is prolonged that the student is prone to let the plane get away from him, become dizzy, or lose his sense of position. This maneuver should not be continued below a thousand feet above the ground.

No judgment of drift or altitude is necessary except to see that the recovery altitude is sufficiently high. The objectives are a constant gliding speed and a constant degree of bank.

The student should be started on spirals using the medium bank and then, in successive practice, the bank should be gradually increased for each spiral until the required bank is attained and held throughout the maneuver.

Slipping, skidding, and vertical variations of the nose are, of course, not permissible.

A constant speed and a constant bank are very important. Too much speed is just as dangerous as not enough, since the tightness of the turn and the position of the controls may eventually result in a spin if the speed is allowed to increase. This is the only normal training maneuver during which a spin may result from the increase of speed and consequently load factor.

Since this is not necessarily a maximum performance maneuver, a speed of from 40 to 50 percent above the stalling speed may be used, but it should not be more.

Particular attention must be given to the recoveries made by the student. Smoothness must be attained, and the controls must be so coordinated that no increase or decrease of speed results when the straight glide is resumed. Considerable practice will be required by most students before this can be accomplished consistently from a 60° spiral held through six or more complete turns.

Toward the end of the practice, the student should be required to make precision recoveries toward an object or point; then he should be given the point before starting the maneuver and instructed to execute a specified number of turns and come out on the point. The greater the number of turns, the more difficult it will be for the average student to retain his orientation.

He should be required to perform spirals in which he holds a constant radius around a point on the ground just as he did when performing turns around a point. This is done by steepening and shallowing the bank at the appropriate places in the turn. The discussion of turns around a point will be equally true for this type of spiral.

Such practice will be of great value as a preliminary to the perfection of accuracy landings, and advanced maneuvers requiring a high degree of orientation, such as lazy eights, chandelles, and emergency landings from high altitudes.

In the event a landing field is available where spiral approaches to landings can be practiced without hazard of conflict with other traffic, the introduction and practice of spiral approaches to landings is recommended.

The spiral approach provides a pattern for use in forced landings from altitudes above 2,000 feet. In practicing this maneuver, the entry is made headed upwind, directly over the intended spot at an altitude suited to the training airplane being used.

The engine is throttled, and a gliding spiral immediately entered around the intended landing spot. This will require correction for wind drift by steepening the bank on downwind headings and shallowing the bank on upwind headings of the spiral, just as when performing the maneuver turns about a point. This will provide an excellent opportunity to judge the direction and velocity of the wind before the final approach is entered.

The turns of the spiral should be planned so as to complete the last at as nearly 1,500 feet as possible, headed upwind, at which point a 360° overhead approach is entered and carried through to a landing. (See fig. 43.)

The practice of this type of approach for landings from higher altitudes than the normal traffic pattern will introduce greater problems of correction for drift than the 180° side approach accuracy landings used at active airports.

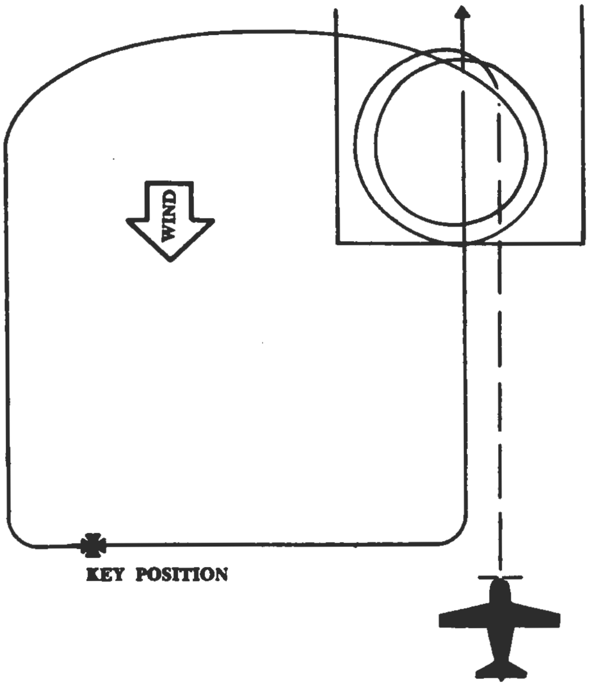

FIGURE 43.—Spiral approach to a landing.

In the event of a power failure or simulated forced landing at a relatively high altitude, the student should promptly select a landing area and initiate a spiral approach.

This gives the student an opportunity to inspect the field he has chosen for ditches, obstructions, and slope, and will allow him to gauge his wind before he commits himself to a final approach.

180° Accuracy Landings

To land an airplane on a predetermined spot is a maneuver called an accuracy landing, although many pilots also term it a "spot" or "precision" landing. The objective is to permit the pilot to acquire the technique of landing his plane where, when, and how he wants to land it.

The maneuver may be accomplished in many different ways. It may be done with power on or power off, in a rectangular or circular pattern, and either with or without slips. Regardless of the method used, certain techniques must be learned, and a high degree of accuracy and precision in the fine details of flying must be mastered.

The following discussion of accuracy work is given to assist in understanding the difficulties faced by the student. Too often it is not realized what the most important factors are, and just as often the student fails to develop skill, accuracy, and judgment where they are most needed.

The technique of the student is a matter of instruction and practice over which the instructor exercises control. The estimation of altitude and gliding distance—the glide angle is a matter of association of the factors affecting them. The ability to develop proficiency in applying this is a personal attribute of the student, dependent on his powers of observation and his ability to make practical use of such observations. However, the instructor can call to the student's attention various factors and explain the methods of association that may be used to arrive at accurate results. The ability to make use of them depends on the aptitude of the student.

Several important factors have a bearing on the successful performance of accuracy landings. Among them, listed in the order of their importance, are: ability to determine and maintain the proper gliding airspeed, ability to estimate, and maneuvering and landing technique.

Of these, the maintenance of the proper airspeed may be rated as about 60 percent of the problem. The minimum glide is that one which will produce the steepest angle of descent with a minimum of airspeed, and the maximum glide is that which will cover the greatest distance over the ground for any given loss of altitude. The minimum glide will result from the lowest practicable airspeed. The maximum glide in calm air will require a gliding speed of about 25 percent below the normal cruising speed, and will require a higher airspeed as the wind velocity increases. This can be illustrated by imagining an airplane gliding at 60 m.p.h. against a wind of equal velocity. In this condition the descent will obviously be vertical, but any increase in airspeed will cause forward motion over the ground.

The gliding speed used for accuracy landings effects a glide somewhere between the minimum and maximum glides. In the average light training airplane the airspeed for the glide and the maximum or normal glide will be very close to the same. Therefore, during that a perfect turn is the most efficient and will result in the maximum performance.

After accuracy landings have been introduced, the student should be required to make all his landings accuracy landings. This is a maneuver which should be practiced throughout any pilot's career, and is his greatest ace in the hole in case of emergencies in all his flying.

Chandelles

The chandelle is a valuable training maneuver of the composite type, requiring a high degree of coordination, control touch, and speed sensing for its perfect execution. A pilot who can perform an excellent chandelle shows, more than anything else, a high degree of planning, because if the climb is started too late, or with an incorrect amount of bank, the maneuver will lack precision.

A chandelle should not be started at an airspeed above maneuvering speed. If normal cruising speed is approximately equal to, but less than maneuvering speed, it can be started from straight-and-level flight. If normal cruising speed is less than maneuvering speed (see definition), the entry may be made from a slight descent to obtain approximate maneuvering speed. In those airplanes which cruise faster than maneuvering speed, it will be necessary to decrease the airspeed to maneuvering speed prior to entry.

A chandelle should be started with the appropriate airspeed and a normal cruise power setting. It is started by entering a coordinated turn with an appropriate angle of bank. This angle of bank should normally not exceed 30°. When the appropriate bank is established, a climbing turn is made with the pitch attitude increasing at a constant rate. As the climb is initiated in airplanes with fixed-pitched pro-

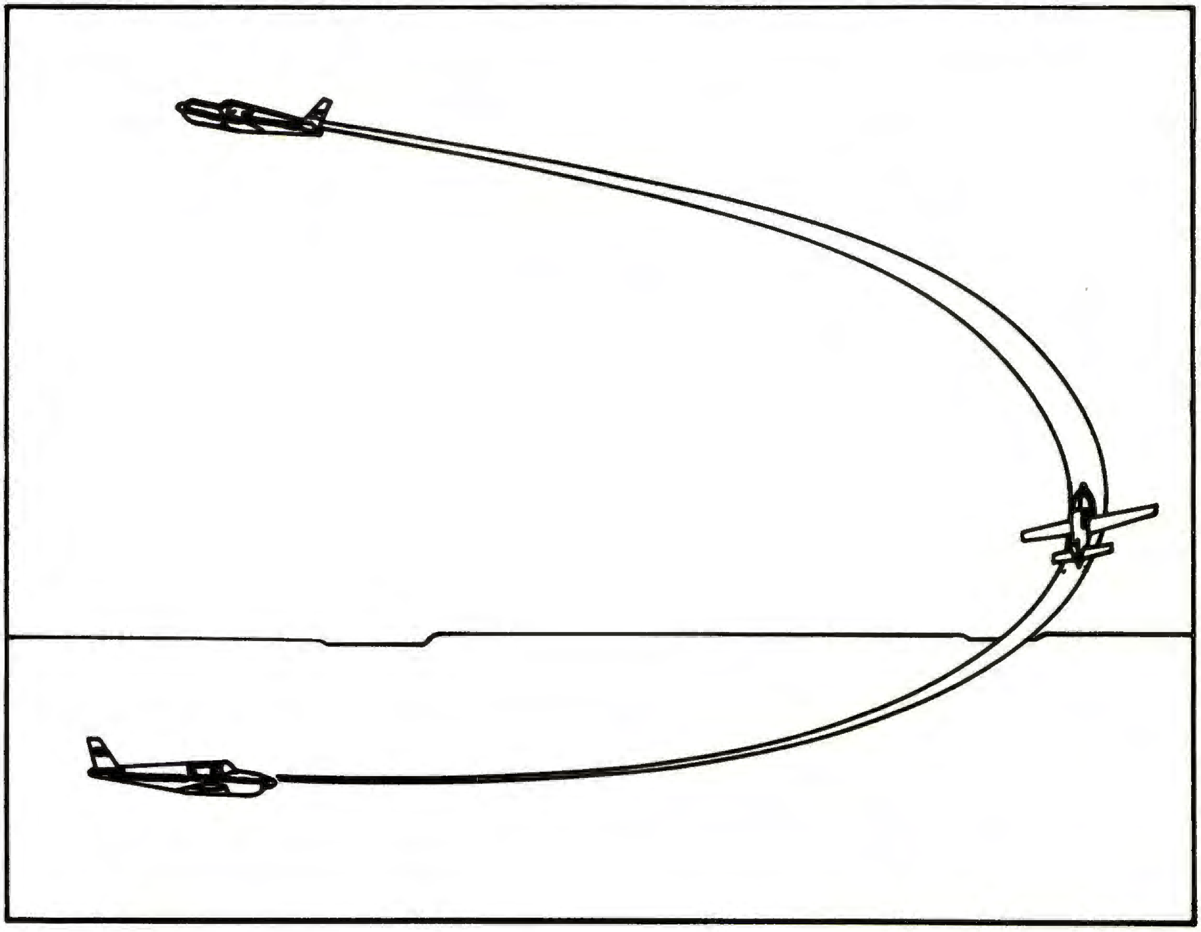

FIGURE 48.—The chandelle.

pellers, full throttle should be applied gradually so that the maximum r.p.m. is not exceeded. In airplanes with constant-speed propellers, power can be left at normal cruise setting. After a 90° turn is completed, recovery is begun and continued so that the airplane arrives on the reciprocal heading from that in which the maneuver was started, with wings level and the airspeed just above a stall. The pitch attitude is then lowered to the level flight attitude as airspeed increases.

Figure 48 shows the maneuver in greater detail. The entry into the bank must be coordinated. If the nose is held straight with opposite rudder during the entry, a slip will result, necessitating a large rudder pressure change once the chandelle is begun. Coordinated rudder during the bank entry will, of course, result in a slight turn, but the length of time during which the plane is being banked should be small, which prevents much turning from the original heading.

As soon as the desired amount of bank is attained, the ailerons are neutralized and up force is applied to the elevators. Thus the plane commences a loop in an oblique plane, with the amount of bank fixed, but seeming to steepen as the maneuver continues. The pitch attitude should increase at a constant rate. When the heading is 90° from the original heading, recovery is begun. From the 90° point to the completion of the recovery, the bank is gradually removed and the pitch attitude is held constant by gradually relaxing pressure on the elevator control until the plane is in climbing flight at near stalling airspeed as the opposite heading is gained. Although pressure on the elevator control is relaxed, due to the slower speed, actual displacement of the controls may increase. Recovery is completed by lowering the nose to the level flight attitude for the existing airspeed after the new heading is established.

Chandelles call for a high degree of planning, as a common error is to either gain the opposite heading with the nose low and with some bank remaining, or to gain the heading with the nose too high and wings level. The perfect chandelle is one in which the plane is flown with perfect coordination, arriving at the reciprocal heading as the bank becomes zero and the airspeed arrives at just above stalling speed.

Whether the maneuver is started crosswind or not is of small consequence. However, it is preferable to start crosswind, executing the first turn into the wind in order that the plane may remain in the immediate area. Students tend to drift out of their practice area, if they do not pay conscious attention to the wind. Wind, at altitude, has neither actual nor visual effect upon a turn.

Although this is called an altitude gaining maneuver with complete reversal of direction, some planes lack sufficient power with which to gain appreciable altitude. The indication of the altimeter at the completion of the maneuver is not the criterion of a correct performance.

The altitude gain in the chandelle is also a function of power used. The higher the power, the more altitude will be gained. In no case may the placard "never exceed" r.p.m. be exceeded. Possibly the smoothest throttle action can be obtained by instructing the student to attempt to hold the r.p.m. to cruising with the throttle, up to its limit. This results in a smooth increase in power to compensate for lost airspeed as the climb progresses.

Common errors in the execution of the chandelle are:

1. Lack of coordination (slipping or skidding—indicated by ball-bank off center).
2. Too shallow an initial bank, resulting in a stall.
3. Too steep an initial bank, resulting in failure to gain maximum performance in the maneuver.
4. Allowing the actual bank to increase during the maneuver.
5. Failure to start recovery at the 90° point.
6. Removing bank before the 180° point is reached.
7. Nose low on recovery with too much airspeed.
8. Roughness.
9. Stalling at any point in the maneuver.
10. Execution of a steep turn, instead of a climbing maneuver.

Lazy Eights

The lazy eight is wholly a training maneuver. In its execution the dive, climb, and

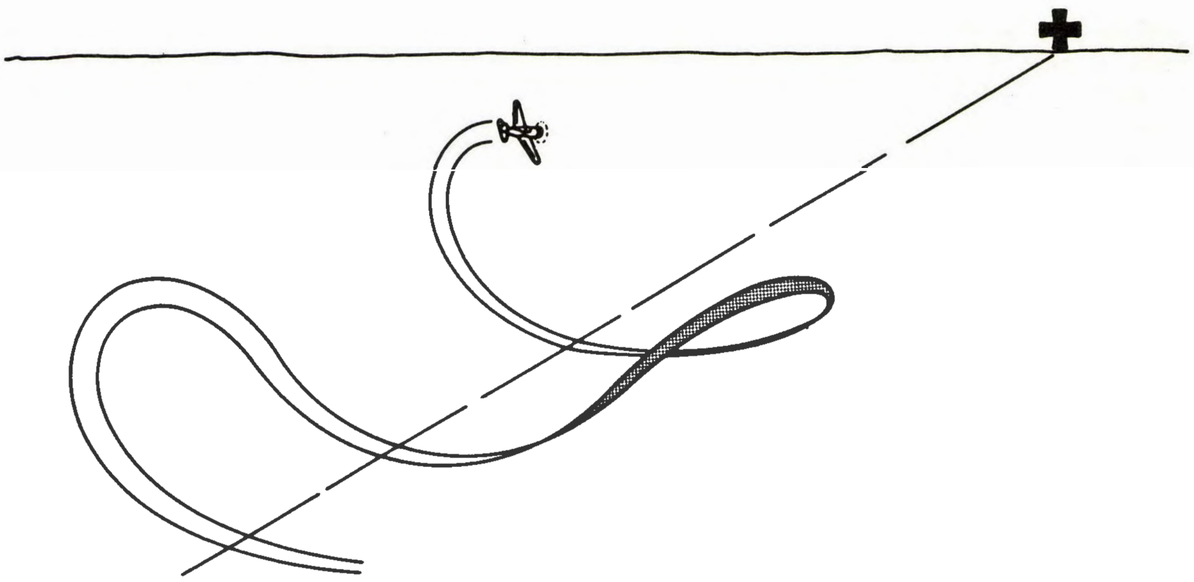

FIGURE 49.—Lazy eights.

turn are all combined, and the combinations are varied and applied throughout the performance range of the airplane. It is the only standard flight maneuver during which at no time do the forces on the controls remain constant.

Such a maneuver has great value to students, since constantly varying forces and attitudes are required. These forces must be constantly coordinated, due not only to the changing combinations of banks, dives, and climbs, but also to the constantly varying airspeed.

The lazy eight is not related to any of the other types of eight already introduced. It is described as an eight only because of the figure apparently drawn on the horizon by the projection of the longitudinal axis of the airplane. The flightpath across the ground is not considered.

Briefly described, the lazy eight amounts to two 180° turns in opposite directions, entered one from the other, with a symmetrical climb and dive performed during each turn. The airplane is not allowed to fly straight at any time, but is constantly rolled from one bank to the other, the wings being level only as the 180° change of direction is reached, and the turn is being reversed.

As an aid to making symmetrical loops in the two turns, a prominent reference point is chosen on the horizon, through which the longitudinal axis will appear to descend at the 90° point in the turns, and through which each wing tip will appear to descend just as the airplane rolls from one bank to the other. If, due to poor visibility or level terrain, no prominent reference point is available on the horizon, a reference below it may be chosen, and a point on the horizon just above it used. The use of a reference point closer than the horizon will result in unsymmetrical loops by causing the turn to be continued beyond the 90° point in a climb so that the nose will appear to descend through the point chosen.

The point should be located either directly upwind or downwind, so that the pattern of the maneuver will not be changed by drift to one side or the other.

Entry is made from straight-and-level flight at normal cruise power and airspeed. When the airplane arrives at a position at which a line from the pilot's eye to the reference point is perpendicular to the longitudinal axis of the airplane, a gradual climbing turn is started toward the reference point. The climbing turn is continued such that the highest pitch attitude is reached after approximately 45° of turn. During this portion of the maneuver the bank should continue to increase and the airspeed will decrease.

From this point, the bank continues to increase and the pitch attitude to decrease. As the airplane completes 90° of turn, the bank should be at its maximum, the airspeed should be at its minimum, and the pitch attitude should be passing through the level flight attitude for that airspeed. It is approximately at this time that the projection of the longitudinal axis of the airplane passes through the reference point chosen earlier. The airplane continues into a diving turn with the pitch attitude continuing to decrease, the airspeed will increase, and the bank should be gradually shallowed. The lowest pitch attitude is reached with approximately 45° of turn remaining of the 180° turn. From this point, the bank should continue to decrease, the pitch attitude should be gradually increased and the airspeed will continue to increase.

The timing should be such that just as the 180° turn is completed, the airplane is passing through the straight-and-level flight attitude, the airspeed should be approximately normal cruise, and the line from the pilot's eye to the reference point should be perpendicular to the longitudinal axis. The airplane should not be stopped in straight-and-level flight, but should progress right into another gradual climbing turn toward the reference point and another 180° turn completed in the same manner as just described.

The eight just described is merely one type of lazy eight. Different maximum and minimum airspeeds may be used, or lesser degrees of turn (say 60° to either side of the axis reference) may be used; power-on or power-off eights may be practiced.

The correct throttle setting is that which will maintain the altitude for the maximum-minimum airspeed used in the loops of the eight. Obviously, if excess throttle were used the plane would climb, while if insufficient throttle were used altitude would be lost.

It should be noted, too, that the attitude and speed of the airplane are continually changing; the control pressures are constantly changing, and a good pilot is continually flying his plane through the maneuver with small, smooth corrections. For excellent coordination, readjustment of aileron pressure will normally produce a cleaner job than readjustment of rudder pressure. The finished maneuver requires that the ball indicator be kept centered.

The result is that this maneuver, while being one of the most beautiful and exhilarating of training maneuvers, is also one which develops subconscious feel, planning, orientation, coordination, and speed sense. It is not possible to do a lazy eight mechanically, because the control pressures required for perfect coordination are never exactly the same.

Common errors are:

1. Using the nose, or top of engine cowl, instead of the true longitudinal axis of the airplane. This will result in unsymmetrical eights, since the airplane must be turned more than 90° to bring the nose, rather than a point directly in front of the pilot's eye, through the reference on the horizon.
2. Attaining too steep a pitch attitude in the climbing turn, which causes falling out of the top.
3. Watching the airplane instead of the points.
4. Excessive dives.
5. Improper planning so that the peaks of the loops, both above and below the horizon, do not come in the proper place.
6. Attempts to hurry through the maneuver.
7. Roughness on the controls, usually caused by attempts to counteract the results of poor planning.
8. Slipping and skidding.
9. Failure to make the portions of the loops above and below the horizon equal.

These maneuvers lend themselves to a wide range of variation by which the instructor can perfect some particular phase of technique in which the student shows deficiency, or eliminate some particular and undesirable tendency he may have developed.

They may be executed with the axis point alone or even without this point. The important feature is the combining of the varying degrees of turn, climb, and dive with the necessary orientation and planning. As long as these are present in the type given, its conformance with any detailed description is unimportant.

Night Flying

Night flying instruction is very important in the training of a competent pilot but should not be undertaken until he has had considerable experience in day flying.

AC 61-21A

Flight Training Handbook

REVISED 1980

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

FLIGHT STANDARDS SERVICE

Before starting the steep power turn the pilot should ensure that the area is clear of other air traffic since the rate of turn will be quite rapid. After establishing the manufacturer's recommended entry speed or the design maneuvering speed, the airplane should be smoothly rolled into a coordinated steep turn with at least 50° of bank. As the turn is being established, back pressure on the elevator control should be smoothly increased to increase the angle of attack. This provides the additional wing lift required to compensate for the increasing centrifugal force.

After the bank has reached approximately 50° the pilot will find that considerable force is required on the elevator control to hold the airplane in level flight—that is, to maintain altitude. Because of this increase in the force applied to the elevators, the load factor increases rapidly as the bank is increased. Additional back elevator pressure increases the angle of attack which, of course, results in an increase in drag. Consequently, power must be added to maintain the entry altitude and the airspeed.

Eventually, as the bank approaches the airplane's maximum angle, the maximum performance or structural limit is being reached. If this limit is exceeded the airplane will be subjected to excessive structural loads, and will lose altitude, or stall. The limit load factor must not be exceeded, so as to prevent structural damage.

During the turn the pilot should not stare at any one object. To maintain altitude, as well as orientation, requires an awareness of the relative position of the nose, the horizon, the wings, and the amount of turn. The pilot who turns by watching only the nose, will have trouble holding altitude constant; on the other hand, the pilot who watches the nose, the horizon, and the wings, can usually hold altitude within a few feet. If the altitude begins to increase, the bank should be increased by coordinated use of aileron and rudder. If the altitude begins to decrease, the bank should be decreased by coordinated use of aileron and rudder. Rudder should never be used alone to control the altitude.

The rollout from the turn should be timed so that the wings reach level flight when the airplane is exactly on the heading from which the maneuver was started. While the recovery is being made, back elevator pressure must be gradually released and power reduced as necessary to maintain the altitude and airspeed.

Steep Spirals

A "steep spiral" is nothing more than a continuous gliding turn, during which a constant radius around a point on the ground is maintained similar to the maneuver "turns around a point." The radius should be such that the steepest bank will be approximately 50° to 55°. The objective of the maneuver is to improve pilot techniques for power-off turns, wind drift control, planning, orientation, and division of attention. This spiral is not only a valuable flight training maneuver, but it has practical application in providing a procedure for dissipating altitude while remaining over a selected spot in preparation for landing, especially for emergency forced landings.

Sufficient altitude must be obtained before starting this maneuver so that the spiral may be continued through a series of at least three 360° turns (Fig. 11–30). However, the maneuver should not be continued below a minimum safe altitude.

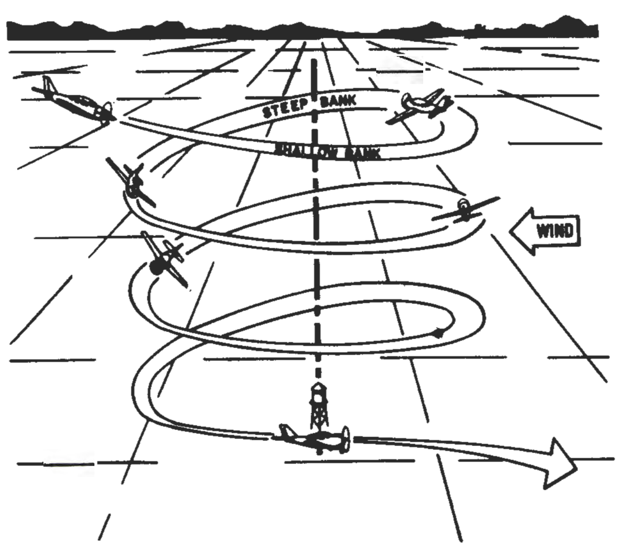

Figure 11–30 Steep Spiral

Operating the engine at idle speed for a prolonged period during the glide may result in excessive engine cooling or spark plug fouling. Therefore, the engine should be cleared periodically by briefly advancing the throttle to normal cruise power, while adjusting the pitch attitude to maintain a constant airspeed. Preferably, this should be done while headed into the wind to minimize any variation in groundspeed and radius of turn.

After the throttle is closed and gliding speed is established, a gliding spiral should be started and a turn of constant radius maintained around the selected spot on the ground. This will require correction for wind drift by steepening the bank on downwind headings and shallowing the bank on upwind headings, just as in the maneuver "turns around a point." During the descending spiral the pilot must judge the direction and speed of the wind at different altitudes and make appropriate changes in the angle of bank to maintain a uniform radius.

A constant airspeed should also be maintained throughout the maneuver. Failure to hold the airspeed constant will cause the radius of turn and necessary angle of bank to vary excessively. On the downwind side of the maneuver, the steeper the bank angle the lower the pitch attitude must be to maintain a given airspeed. Conversely, on the upwind side, as the bank angle becomes shallower, the pitch attitude must be raised to maintain the proper airspeed. This is necessary because the airspeed tends to change as the bank is changed from shallow to steep to shallow.

During practice of the maneuver the pilot should execute a specific number of turns and roll out toward a definite object or on a specific heading. During the rollout, smoothness, is essential, and the use of controls must be so coordinated that no increase or decrease of speed results when the straight glide is resumed.

Descents (Maximum Distance Glides)

The best angle of glide is one that allows the airplane to travel the greatest distance over the ground with the least loss of altitude. This is the airplane's maximum L/D (lift over drag) and is usually expressed as a ratio. For example, an airplane having an L/D or glide ratio of 10:1 will travel 10 feet forward for every foot it descends.

For a particular airplane the manufacturer recommends an airspeed and configuration that will provide the maximum glide distance. This speed (best glide speed) usually found in the Airplane Flight Manual or Pilot's Operating Manual, is of primary importance because if the engine should fail in flight the pilot's chief concern may be whether or not the airplane can glide far enough to reach a suitable landing area.

The objective of this maneuver, then, is to establish a glide that will allow the airplane to travel forward the greatest possible distance from a given altitude.

To establish the glide, the landing gear and flaps should first be retracted to eliminate unwanted drag. The throttle should be reduced to idle, the propeller placed in full high pitch (low RPM) position, and the airplane then eased into a glide until the proper airspeed is established. If the airplane's nose is lowered excessively, the airplane will go into too steep a glide, and naturally will cover very little horizontal distance. On the other hand if the nose is raised too high and too much airspeed is lost, the airplane will settle and descend at a steeper angle than if the nose were somewhat lower.

When practicing the power-off descents, the engine should be cleared periodically, as is done in the steep spiral maneuver, to prevent excessive cooling and fouling, and of course the descent should be terminated at a safe altitude. Care must be exercised when advancing the throttle to avoid overstressing the engine.

Descents (Emergency)

This maneuver is a procedure for establishing the fastest practical rate of descent during emergency conditions which may arise as the result of an uncontrollable fire, a sudden loss of cabin pressurization, or any other situation demanding an immediate and rapid descent. The objective, then, is to descend the airplane as soon and as rapidly as possible, within the limitations of the airplane, to an altitude from which a safe landing can be made, or an altitude where pressurization or supplemental oxygen is not needed.

The simulated emergency descent must be started high enough to permit recovery at a safe altitude. Before entering the maneuver, the area below must be free of other air traffic, since the loss of altitude is quite rapid. *In no case* should the airplane's never-exceed speed (V_{ne}), maximum gear-extended speed (V_{le}), or maximum flap-extended speed (V_{fe}) be exceeded.

Generally, the maneuver should be performed with the airplane configured as recommended by the manufacturer. Except when prohibited by the manufacturer, the power should be reduced to idle, and the propeller control (if so equipped), should be placed in the low pitch (or high RPM) position. This will allow the propeller to act as an aerodynamic brake to help prevent excessive airspeed during the descent. As quickly as practical, the landing gear and full flaps should be extended to provide maximum drag so that a descent as rapidly as possible can be made without excessive airspeed. This, of course, should be done only in accordance with the airplane manufacturer's recommendations.

To maintain *positive* load factors (G forces) and for the purpose of clearing the area below, a 30° to 45° bank should be established for at least a 90° heading change while initiating the descent.

Normally during student training, as soon as all prescribed procedures are completed and the descent is established and stabilized, the maneuver should be terminated. In airplanes with piston engines, a prolonged practice emergency descent should be avoided to prevent excessive cooling of the cylinders.

Chandelles

A "chandelle" is a climbing turn beginning from approximately straight-and-level flight, and ending at the completion of 180° of turn in a wings-level, nose-high attitude at the minimum controllable airspeed (Fig. 11–31). The maneuver demands that the maximum flight performance of the airplane be obtained; that is, the airplane should gain the most altitude possible for a given degree of bank and power setting without stalling. However, since numerous atmospheric variables beyond control of the pilot will affect the specific amount of altitude gained, the altitude gain is not a criterion of the quality of the maneuver.

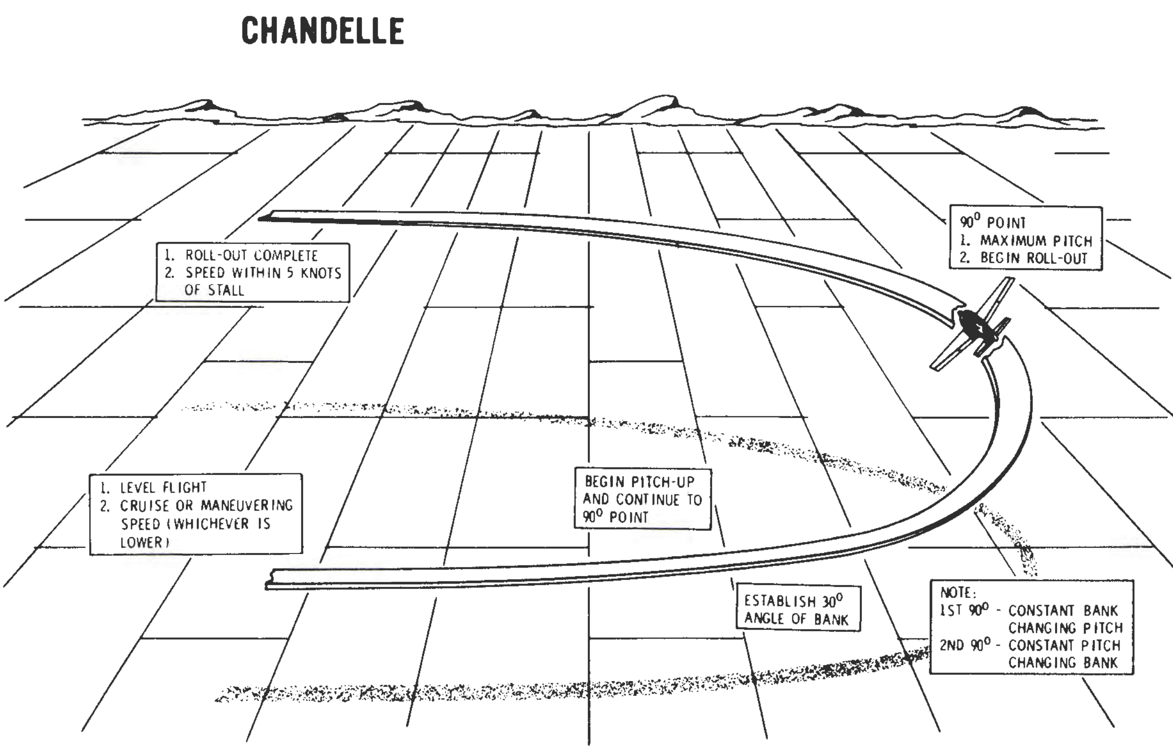

Figure 11–31 Chandelle

The objective of this maneuver is to develop the pilot's coordination, orientation, planning, and feel for maximum-performance flight, and to develop positive control techniques at varying airspeeds and attitudes.

Prior to starting a chandelle, the flaps and gear (if retractable) should be in the UP position, power set to cruise condition, the airspace behind and above clear of other air traffic. A chandelle should be started at any speed no greater than the maximum entry speed recommended by the manufacturer—in most cases not above the airplane's design maneuvering speed.

After the appropriate airspeed and power setting have been established, the chandelle is started by smoothly entering a coordinated turn with an angle of bank appropriate for the airplane being flown. Normally, this angle of bank should not exceed approximately 30°. After the appropriate bank is established, a climbing turn should be started by smoothly applying back elevator pressure to increase the pitch attitude at a constant rate and to attain the highest pitch attitude as 90° of turn is completed. As the climb is initiated in airplanes with fixed-pitch propellers, full throttle may be applied but must be applied *gradually* so that the maximum allowable RPM is not exceeded. In airplanes with constant-speed propellers, power may be left at the normal cruise setting. (Prior to starting the maneuver, RPM may be increased to climb or takeoff setting and then throttle increased as the climb is started.)

Once the bank has been established, the angle of bank should remain constant until 90° of turn is completed. Although the degree of bank is fixed during this climbing turn, it may appear to increase and, in fact, actually will tend to increase if allowed to do so as the maneuver continues.

When the turn has progressed 90° from the original heading, the pilot should begin rolling out of the bank at a constant rate while maintaining a constant-pitch attitude. Since the angle of bank will be decreasing during the rollout, the vertical component of lift will increase slightly. For this reason, it may be necessary to release a slight amount of back elevator pressure in order to keep the nose of the airplane from rising higher.

As the wings are being leveled at the completion of 180° of turn, the pitch attitude should be noted by checking the outside references and the attitude indicator. This pitch attitude should be held momentarily while the airplane is at the minimum controllable airspeed. Then the pitch attitude may be gently reduced to return to straight-and-level cruise flight.

Since the airspeed is constantly decreasing throughout the maneuver, the effects of engine torque become more and more prominent. Therefore, right rudder pressure must be gradually increased to control yaw and maintain a constant rate of turn and to keep the airplane in coordinated flight. The pilot should maintain coordinated flight by the "feel" of pressures being applied on the controls, and by the ball instrument of the turn-and-slip indicator. If coordinated flight is being maintained, the ball will remain in the center of the race.

To roll out of a left chandelle, the left aileron must be lowered to raise the left wing. This creates more drag than the aileron on the ring wing, resulting in a tendency for the airplane to yaw to the left. With the low airspeed at this point, torque effect tries to make the airplane yaw to the left even more. Thus, there are two forces pulling the airplane's nose to the left—aileron drag and torque. To maintain coordinated flight, considerable right rudder pressure must be used during the rollout to overcome the effects of aileron drag and torque.

In a chandelle to the right, when control pressure is applied to begin the rollout, the aileron on the right wing is lowered. This creates more drag on that wing and tends to make the airplane yaw to the right. At the same time, however, the effect of torque at the low airspeed is causing the airplane's nose to yaw to the left. Thus, aileron drag pulling the nose to the right and torque pulling to the left, tend to neutralize each other. If excessive left rudder pressure is applied, the rollout will be uncoordinated.

The rollout to the left can usually be accomplished with very little left rudder, since the effects of aileron drag and torque tend to neutralize each other. *Releasing* some right rudder, which has been applied to correct for torque, will normally give the same effect as applying left rudder pressure. When the wings become level and the ailerons are neutralized, the aileron drag disappears. At this time, however, because of the low airspeed and high power, the effects of torque become the more prominent force and must continue to be controlled with rudder pressure.

A rollout to the left, therefore, is accomplished mainly by applying aileron pressure. During the rollout, right rudder pressure should be gradually released, and left rudder applied only as necessary to maintain coordination. Even when the wings are level and aileron pressure is released, right rudder pressure must be held to counteract torque and hold the nose straight.

Lazy 8

This maneuver derives its name from the manner in which the extended longitudinal axis of the airplane is made to trace a flight pattern in the form of a figure 8 lying on its side (a "Lazy" 8) (Fig. 11-32). Objective of the Lazy 8 is to develop the pilot's feel for varying control forces, and the ability to plan and remain oriented while maneuvering the airplane with positive, accurate control. It requires constantly changing control pressures necessitated by changing combinations of climbing and descending turns at varying airspeeds. This is a maneuver often used to develop and demonstrate the pilot's mastery of the airplane in maximum performance flight situations.

A "Lazy 8" consists of two 180° turns, in opposite directions, while making a climb and a descent in a symmetrical pattern during each of the turns. At no time throughout the Lazy 8 is the airplane flown straight and level; instead, it is rolled directly from one bank to the other with the wings level only at the moment the turn is reversed at the completion of each 180° change in heading.

As an aid to making symmetrical loops of the 8 during each turn, prominent reference points should be selected on the horizon. The reference points selected should be 45°, 90°, and 135° from the direction in which the maneuver is begun.

Prior to performing a Lazy 8, the airspace behind and above should be clear of other air traffic. The maneuver should be entered from

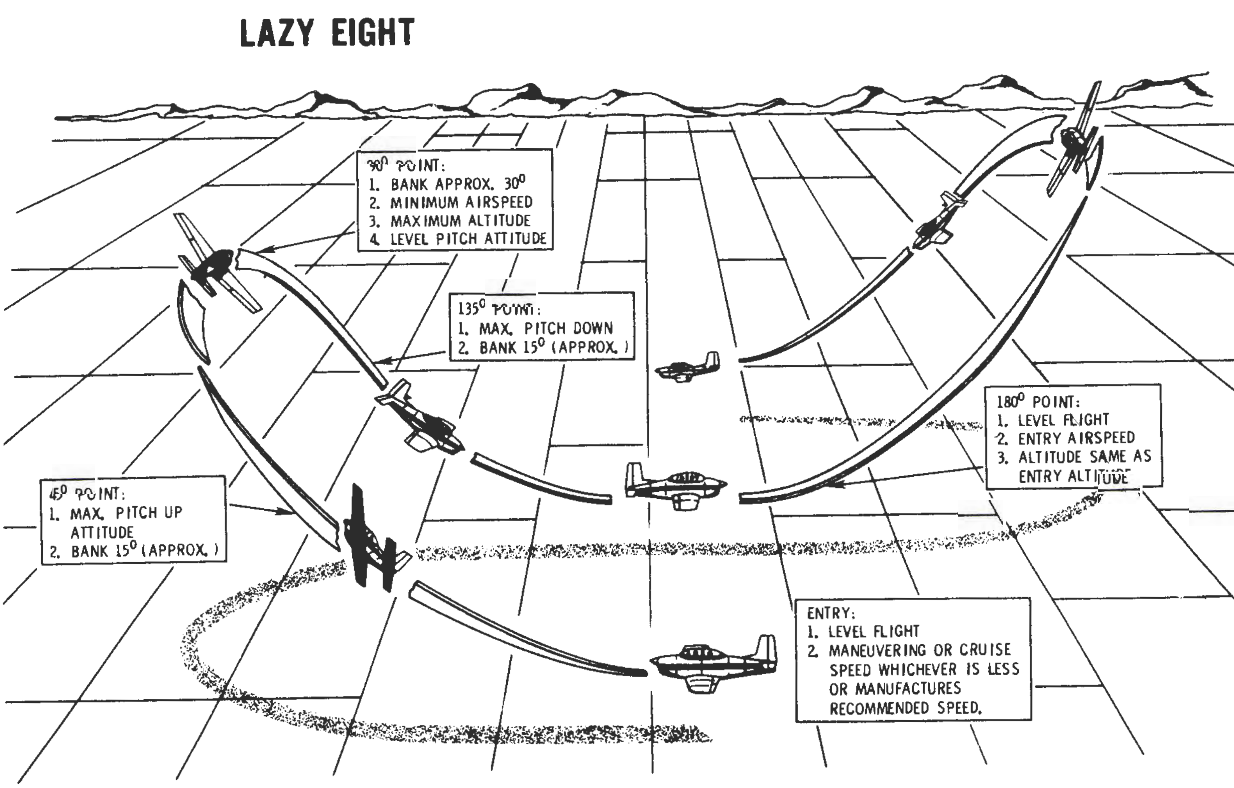

Figure 11-32 Lazy Eight

straight-and-level flight at normal cruise power and at the airspeed recommended by the manufacturer or at the airplane's design maneuvering speed.

The maneuver is started from level flight with a gradual climbing turn in the direction of the 45° reference point. The climbing turn should be planned and controlled so that the maximum pitch-up attitude is reached at the 45° point. The rate of rolling into the bank must be such as to prevent the rate of turn from becoming too rapid. As the pitch attitude is raised the airspeed decreases, causing the rate of turn to increase. Since the bank also is being increased, it too causes the rate of turn to increase. Unless the maneuver is begun with a slow rate of roll, the combination of increasing pitch and increasing bank will cause the rate of turn to be so rapid that the 45° reference point will be reached before the highest pitch attitude is attained.

At the 45° point, the pitch attitude should be at maximum and the angle of bank continuing to increase. Also, at the 45° point, the pitch attitude should start to decrease slowly toward the horizon and the 90° reference point. Since the airspeed is still decreasing, right-rudder pressure will have to be applied to counteract torque.

As the airplane's nose is being lowered toward the 90° reference point, the bank should continue to increase. Due to the decreasing airspeed, a slight amount of opposite aileron pressure may be required to prevent the bank from becoming too steep. When the airplane completes 90° of the turn, the bank should be at the maximum angle (approximately 30°), the airspeed should be at its minimum (5–10 knots above stall speed), and the airplane pitch attitude should be passing through level flight. It is at this time that an imaginary line, extending from the pilot's eye and parallel to the longitudinal axis of the airplane, passes through the 90° reference point.

Lazy 8's normally should be performed with no more than approximately a 30° bank. Steeper banks may be used but control touch and technique must be developed to a much higher degree than when the maneuver is performed with a shallower bank.

The pilot should not hesitate at this point but should continue to fly the airplane into a descending turn so that the airplane's nose describes the same size loop below the horizon as it did above. As the pilot's reference line passes through the 90° point, the bank should be decreased gradually, and the airplane's nose allowed to continue lowering. When the airplane has turned 135°, the nose should be in its lowest pitch attitude. The airspeed will be increasing during this descending turn so it will be necessary to gradually relax rudder and aileron pressure and to simultaneously raise the nose and roll the wings level. As this is being accomplished, the pilot should note the amount of turn remaining and adjust the rate of rollout and pitch change so that the wings become level and the original airspeed is attained in level flight just as the 180° point is reached. Upon reaching that point, a climbing turn should be started immediately in the opposite direction toward the selected reference points to complete the second half of the eight in the same manner as the first half.

Due to the decreasing airspeed considerable right-rudder pressure must be gradually applied to counteract torque at the top of the eight in both the right and left turns. The pressure will be greatest at the point of lowest airspeed.

More right-rudder pressure will be needed during the climbing turn to the right than in the turn to the left because more torque correction is needed to prevent yaw from decreasing the rate of turn. In the left climbing turn the torque will tend to contribute to the turn; consequently, less rudder pressure is needed. It will be noted that the controls are slightly crossed in the right climbing turn because of the need for left aileron pressure to prevent over-banking and right rudder to overcome torque.

The correct power setting for the lazy eight is that which will maintain the altitude for the maximum and minimum airspeeds used during the climbs and descents of the eight. Obviously, if excess power were used, the airplane would have gained altitude when the maneuver is completed, while if insufficient power were used, altitude would have been lost.

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Airplane Flying Handbook

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FAA-H-8083-3A

AIRPLANE FLYING HANDBOOK

2004

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service

STEEP SPIRAL

The objective of this maneuver is to improve pilot techniques for airspeed control, wind drift control, planning, orientation, and division of attention. The steep spiral is not only a valuable flight training maneuver, but it has practical application in providing a procedure for dissipating altitude while remaining over a selected spot in preparation for landing, especially for emergency forced landings.

A steep spiral is a constant gliding turn, during which a constant radius around a point on the ground is maintained similar to the maneuver, turns around a point. The radius should be such that the steepest bank will not exceed 60°. Sufficient altitude must be obtained before starting this maneuver so that the spiral may be continued through a series of at least three 360° turns. [Figure 9-2] The maneuver should not be continued below 1,000 feet above the surface unless performing an emergency landing in conjunction with the spiral.

Operating the engine at idle speed for a prolonged period during the glide may result in excessive engine cooling or spark plug fouling. The engine should be cleared periodically by briefly advancing the throttle to normal cruise power, while adjusting the pitch attitude to maintain a constant airspeed. Preferably, this should be done while headed into the wind to minimize any variation in groundspeed and radius of turn.

After the throttle is closed and gliding speed is established, a gliding spiral should be started and a turn of constant radius maintained around the selected spot on the ground. This will require correction for wind drift by steepening the bank on downwind headings and shallowing the bank on upwind headings, just as in the maneuver, turns around a point. During the descending spiral, the pilot must judge the direction and speed of the wind at different altitudes and make appropriate changes in the angle of bank to maintain a uniform radius.

A constant airspeed should also be maintained throughout the maneuver. Failure to hold the airspeed constant will cause the radius of turn and necessary angle of bank to vary excessively. On the downwind side of the maneuver, the steeper the bank angle, the lower the pitch attitude must be to maintain a given airspeed. Conversely, on the upwind side, as the bank angle becomes shallower, the pitch attitude must be raised to maintain the proper airspeed. This is necessary because the airspeed tends to change as the bank is changed from shallow to steep to shallow.

During practice of the maneuver, the pilot should execute three turns and roll out toward a definite object or on a specific heading. During the rollout, smoothness is essential, and the use of controls must be so coordinated that no increase or decrease of speed results when the straight glide is resumed.

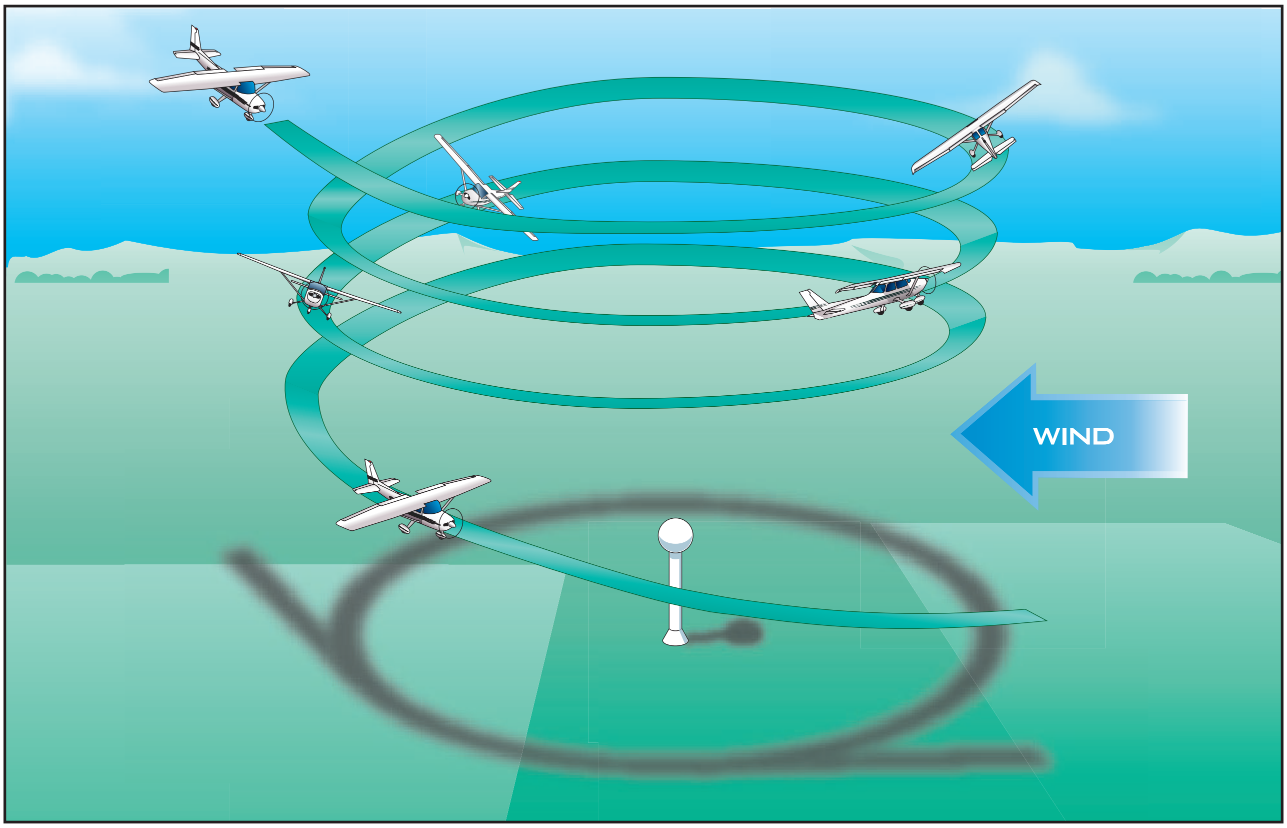

Figure 9-2. Steep spiral.

Common errors in the performance of steep spirals are:

- Failure to adequately clear the area.
- Failure to maintain constant airspeed.
- Poor coordination, resulting in skidding and/or slipping.
- Inadequate wind drift correction.
- Failure to coordinate the controls so that no increase/decrease in speed results when straight glide is resumed.
- Failure to scan for other traffic.
- Failure to maintain orientation.

CHANDELLE

The objective of this maneuver is to develop the pilot's coordination, orientation, planning, and accuracy of control during maximum performance flight.

A chandelle is a maximum performance climbing turn beginning from approximately straight-and-level flight, and ending at the completion of a precise 180° of turn in a wings-level, nose-high attitude at the minimum controllable airspeed. [Figure 9-3] The maneuver demands that the maximum flight performance of the airplane be obtained; the airplane should gain the most altitude possible for a given degree of bank and power setting without stalling. Since numerous atmospheric variables beyond control of the pilot will affect the specific amount of altitude gained, the quality of the performance of the maneuver is not judged solely on the altitude gain, but by the pilot's overall proficiency as it pertains to climb performance for the power/bank combination used, and to the elements of piloting skill demonstrated.

Prior to starting a chandelle, the flaps and gear (if retractable) should be in the UP position, power set to cruise condition, and the airspace behind and above clear of other air traffic. The maneuver should be entered from straight-and-level flight (or a shallow dive) and at a speed no greater than the maximum entry speed recommended by the manufacturer—in most cases not above the airplane's design maneuvering speed (V_A).

After the appropriate airspeed and power setting have been established, the chandelle is started by smoothly entering a coordinated turn with an angle of bank appropriate for the airplane being flown. Normally, this angle of bank should not exceed approximately 30°. After the appropriate bank is established, a climbing turn should be started by smoothly applying back-elevator pressure to increase the pitch attitude at a constant rate and to attain the highest pitch attitude as 90° of turn is completed. As the climb is initiated in airplanes with fixed-pitch propellers, full throttle may be applied, but is applied gradually so that the maximum allowable r.p.m. is not exceeded. In airplanes with constant-speed propellers, power may be left at the normal cruise setting.

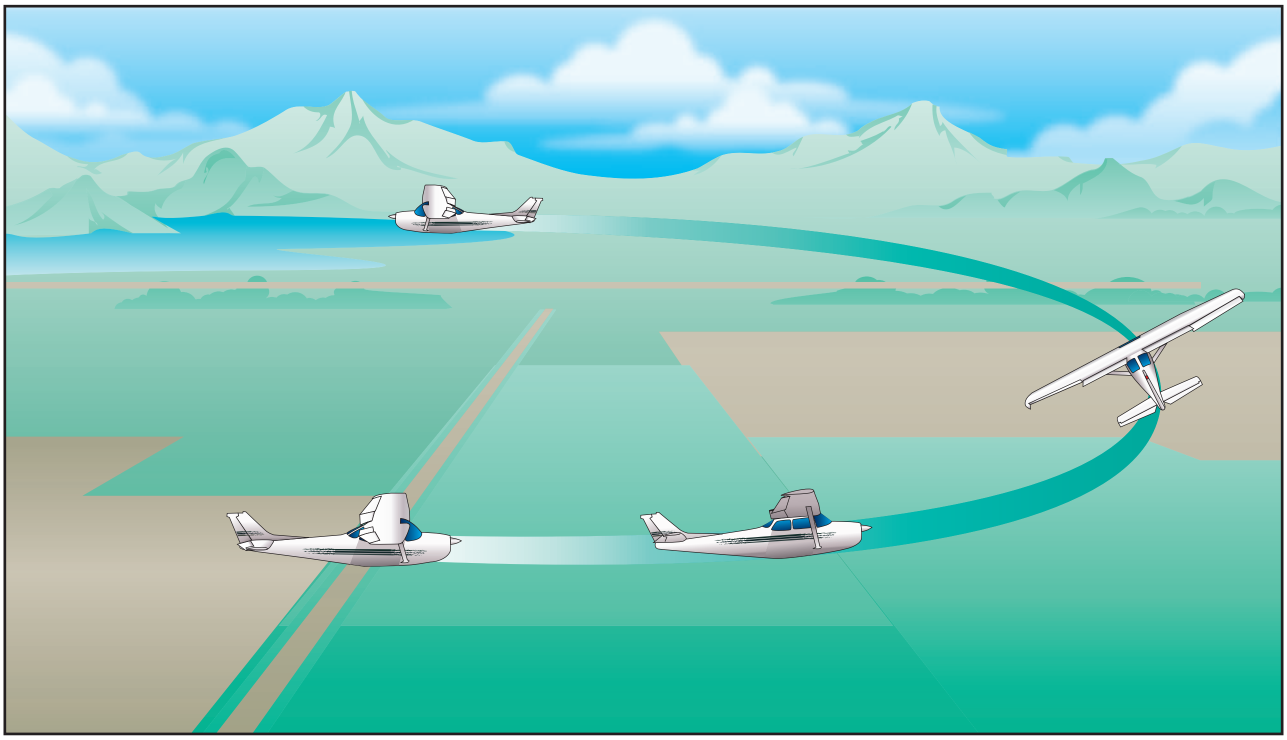

Figure 9-3. Chandelle.

Once the bank has been established, the angle of bank should remain constant until 90° of turn is completed. Although the degree of bank is fixed during this climbing turn, it may appear to increase and, in fact, actually will tend to increase if allowed to do so as the maneuver continues.

When the turn has progressed 90° from the original heading, the pilot should begin rolling out of the bank at a constant rate while maintaining a constant-pitch attitude. Since the angle of bank will be decreasing during the rollout, the vertical component of lift will increase slightly. For this reason, it may be necessary to release a slight amount of back-elevator pressure in order to keep the nose of the airplane from rising higher.

As the wings are being leveled at the completion of 180° of turn, the pitch attitude should be noted by checking the outside references and the attitude indicator. This pitch attitude should be held momentarily while the airplane is at the minimum controllable airspeed. Then the pitch attitude may be gently reduced to return to straight-and-level cruise flight.

Since the airspeed is constantly decreasing throughout the maneuver, the effects of engine torque become more and more prominent. Therefore, right-rudder pressure is gradually increased to control yaw and maintain a constant rate of turn and to keep the airplane in coordinated flight. The pilot should maintain coordinated flight by the feel of pressures being applied on the controls and by the ball instrument of the turn-and-slip indicator. If coordinated flight is being maintained, the ball will remain in the center of the race.

To roll out of a left chandelle, the left aileron must be lowered to raise the left wing. This creates more drag than the aileron on the right wing, resulting in a tendency for the airplane to yaw to the left. With the low airspeed at this point, torque effect tries to make the airplane yaw to the left even more. Thus, there are two forces pulling the airplane's nose to the left—aileron drag and torque. To maintain coordinated flight, considerable right-rudder pressure is required during the rollout to overcome the effects of aileron drag and torque.

In a chandelle to the right, when control pressure is applied to begin the rollout, the aileron on the right wing is lowered. This creates more drag on that wing and tends to make the airplane yaw to the right. At the same time, the effect of torque at the lower airspeed is causing the airplane's nose to yaw to the left. Thus, aileron drag pulling the nose to the right and torque pulling to the left, tend to neutralize each other. If excessive left-rudder pressure is applied, the rollout will be uncoordinated.

The rollout to the left can usually be accomplished with very little left rudder, since the effects of aileron drag and torque tend to neutralize each other. Releasing some right rudder, which has been applied to correct for torque, will normally give the same effect as applying left-rudder pressure. When the wings become level and the ailerons are neutralized, the aileron drag disappears. Because of the low airspeed and high power, the effects of torque become the more prominent force and must continue to be controlled with rudder pressure.

A rollout to the left is accomplished mainly by applying aileron pressure. During the rollout, right-rudder pressure should be gradually released, and left rudder applied only as necessary to maintain coordination. Even when the wings are level and aileron pressure is released, right-rudder pressure must be held to counteract torque and hold the nose straight.

Common errors in the performance of chandelles are:

- Failure to adequately clear the area.
- Too shallow an initial bank, resulting in a stall.
- Too steep an initial bank, resulting in failure to gain maximum performance.
- Allowing the actual bank to increase after establishing initial bank angle.
- Failure to start the recovery at the 90° point in the turn.
- Allowing the pitch attitude to increase as the bank is rolled out during the second 90° of turn.
- Removing all of the bank before the 180° point is reached.
- Nose low on recovery, resulting in too much airspeed.
- Control roughness.
- Poor coordination (slipping or skidding).
- Stalling at any point during the maneuver.
- Execution of a steep turn instead of a climbing maneuver.
- Failure to scan for other aircraft.
- Attempting to perform the maneuver by instrument reference rather than visual reference.

LAZY EIGHT

The lazy eight is a maneuver designed to develop perfect coordination of controls through a wide range of airspeeds and altitudes so that certain accuracy points are reached with planned attitude and airspeed. In its execution, the dive, climb, and turn are all combined, and the combinations are varied and applied throughout the performance range of the airplane. It is the only standard flight training maneuver during which at no time do the forces on the controls remain constant.

The lazy eight as a training maneuver has great value since constantly varying forces and attitudes are required. These forces must be constantly coordinated, due not only to the changing combinations of banks, dives, and climbs, but also to the constantly varying airspeed. The maneuver helps develop subconscious feel, planning, orientation, coordination, and speed sense. It is not possible to do a lazy eight mechanically, because the control pressures required for perfect coordination are never exactly the same.

This maneuver derives its name from the manner in which the extended longitudinal axis of the airplane is made to trace a flight pattern in the form of a figure 8 lying on its side (a lazy 8). [Figure 9-4]

A lazy eight consists of two 180° turns, in opposite directions, while making a climb and a descent in a symmetrical pattern during each of the turns. At no time throughout the lazy eight is the airplane flown straight and level; instead, it is rolled directly from one bank to the other with the wings level only at the moment the turn is reversed at the completion of each 180° change in heading.

As an aid to making symmetrical loops of the 8 during each turn, prominent reference points should be selected on the horizon. The reference points selected should be 45°, 90°, and 135° from the direction in which the maneuver is begun.

Prior to performing a lazy eight, the airspace behind and above should be clear of other air traffic. The maneuver should be entered from straight-and-level flight at normal cruise power and at the airspeed recommended by the manufacturer or at the airplane's design maneuvering speed.

The maneuver is started from level flight with a gradual climbing turn in the direction of the 45° reference point. The climbing turn should be planned and controlled so that the maximum pitch-up attitude is reached at the 45° point. The rate of rolling into the bank must be such as to prevent the rate of turn from becoming too rapid. As the pitch attitude is raised, the airspeed decreases, causing the rate of turn to increase. Since the bank also is being increased, it too causes the rate of turn to increase. Unless the maneuver is begun with a slow rate of roll, the combination of increasing pitch and increasing bank will cause the rate of turn to be so rapid that the 45° reference point will be reached before the highest pitch attitude is attained.

At the 45° point, the pitch attitude should be at maximum and the angle of bank continuing to

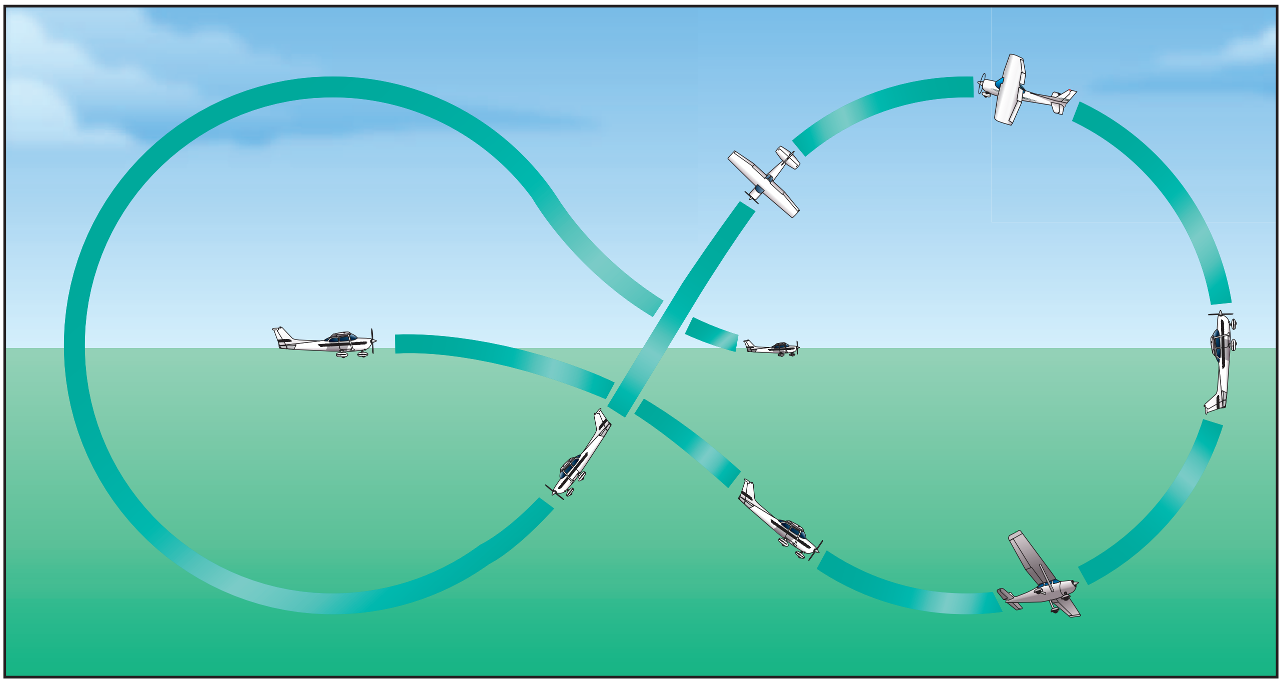

Figure 9-4. Lazy eight.

increase. Also, at the 45° point, the pitch attitude should start to decrease slowly toward the horizon and the 90° reference point. Since the airspeed is still decreasing, right-rudder pressure will have to be applied to counteract torque.

As the airplane's nose is being lowered toward the 90° reference point, the bank should continue to increase. Due to the decreasing airspeed, a slight amount of opposite aileron pressure may be required to prevent the bank from becoming too steep. When the airplane completes 90° of the turn, the bank should be at the maximum angle (approximately 30°), the airspeed should be at its minimum (5 to 10 knots above stall speed), and the airplane pitch attitude should be passing through level flight. It is at this time that an imaginary line, extending from the pilot's eye and parallel to the longitudinal axis of the airplane, passes through the 90° reference point.

Lazy eights normally should be performed with no more than approximately a 30° bank. Steeper banks may be used, but control touch and technique must be developed to a much higher degree than when the maneuver is performed with a shallower bank.

The pilot should not hesitate at this point but should continue to fly the airplane into a descending turn so that the airplane's nose describes the same size loop below the horizon as it did above. As the pilot's reference line passes through the 90° point, the bank should be decreased gradually, and the airplane's nose allowed to continue lowering. When the airplane has turned 135°, the nose should be in its lowest pitch attitude. The airspeed will be increasing during this descending turn, so it will be necessary to gradually relax rudder and aileron pressure and to simultaneously raise the nose and roll the wings level. As this is being accomplished, the pilot should note the amount of turn remaining and adjust the rate of rollout and pitch change so that the wings become level and the original airspeed is attained in level flight just as the 180° point is reached. Upon returning to the starting altitude and the 180° point, a climbing turn should be started immediately in the opposite direction toward the selected reference points to complete the second half of the eight in the same manner as the first half. [Figure 9-5]

Due to the decreasing airspeed, considerable right-rudder pressure is gradually applied to counteract torque at the top of the eight in both the right and left turns. The pressure will be greatest at the point of lowest airspeed.

More right-rudder pressure will be needed during the climbing turn to the right than in the turn to the left because more torque correction is needed to prevent yaw from decreasing the rate of turn. In the left climbing turn, the torque will tend to contribute to the

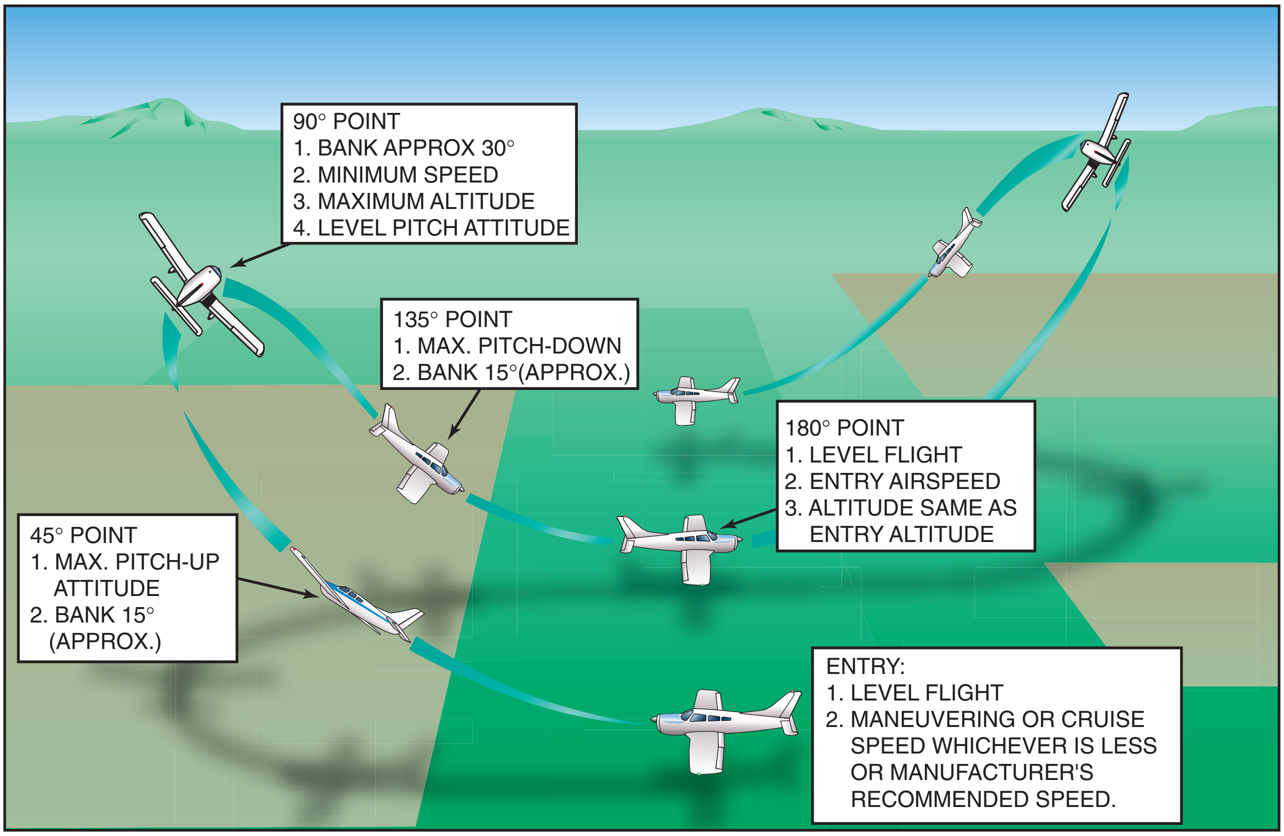

Figure 9-5. Lazy eight.

turn; consequently, less rudder pressure is needed. It will be noted that the controls are slightly crossed in the right climbing turn because of the need for left aileron pressure to prevent overbanking and right rudder to overcome torque.

The correct power setting for the lazy eight is that which will maintain the altitude for the maximum and minimum airspeeds used during the climbs and descents of the eight. Obviously, if excess power were used, the airplane would have gained altitude when the maneuver is completed; if insufficient power were used, altitude would have been lost.

Common errors in the performance of lazy eights are:

- Failure to adequately clear the area.
- Using the nose, or top of engine cowl, instead of the true longitudinal axis, resulting in unsymmetrical loops.
- Watching the airplane instead of the reference points.
- Inadequate planning, resulting in the peaks of the loops both above and below the horizon not coming in the proper place.
- Control roughness, usually caused by attempts to counteract poor planning.
- Persistent gain or loss of altitude with the completion of each eight.
- Attempting to perform the maneuver rhythmically, resulting in poor pattern symmetry.
- Allowing the airplane to “fall” out of the tops of the loops rather than flying the airplane through the maneuver.
- Slipping and/or skidding.
- Failure to scan for other traffic.

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- Ineffective use of power
- Inadequate airspeed control
- Becoming disoriented
- Performing by reference to the flight instrument 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

Steep Spiral

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. This maneuver is especially effective for emergency descents or landings. A steep spiral is a gliding turn where the pilot maintains a constant radius around a surface-based reference point while rapidly descending—similar to the turns around a point maneuver. Sufficient altitude must be gained prior to practicing the maneuver so that at least three 360° turns are completed. *[Figure 9-2]* The maneuver should not be allowed to continue below 1,500 feet above ground level (AGL) unless an actual emergency exists.

The steep spiral is initiated by properly clearing the airspace for air traffic and hazards. In general, the throttle is closed to idle, carburetor heat is applied if equipped, and gliding speed is established. Once the proper airspeed is attained, the pitch should be lowered and the airplane rolled to the desired bank angle as the reference point is reached. The steepest bank should not exceed 60°. The gliding spiral should be a turn of constant radius while maintaining the airplane's position to the reference. This can only be accomplished by proper correction for wind drift by steepening the bank on downwind headings and shallowing the bank on upwind headings, just as in the maneuver, turns around a point. During the steep spiral, the pilot must continually correct for any changes in wind direction and velocity to maintain a constant radius.

Operating the engine at idle speed for any prolonged period during the glide may result in excessive engine cooling, spark plug fouling, or carburetor ice. To assist in avoiding these issues, the throttle should be periodically advanced to normal cruise power and sustained for a few seconds. If equipped, monitoring cylinder head temperatures provides a pilot with additional information on engine cooling. When advancing the throttle, the pitch attitude must be adjusted to maintain a constant airspeed and, preferably, this should be done when headed into the wind.

Maintaining a constant airspeed throughout the maneuver is an important skill for a pilot to develop. This is necessary because the airspeed tends to fluctuate as the bank angle is changed throughout the maneuver. The pilot should anticipate pitch corrections as the bank angle is varied throughout the

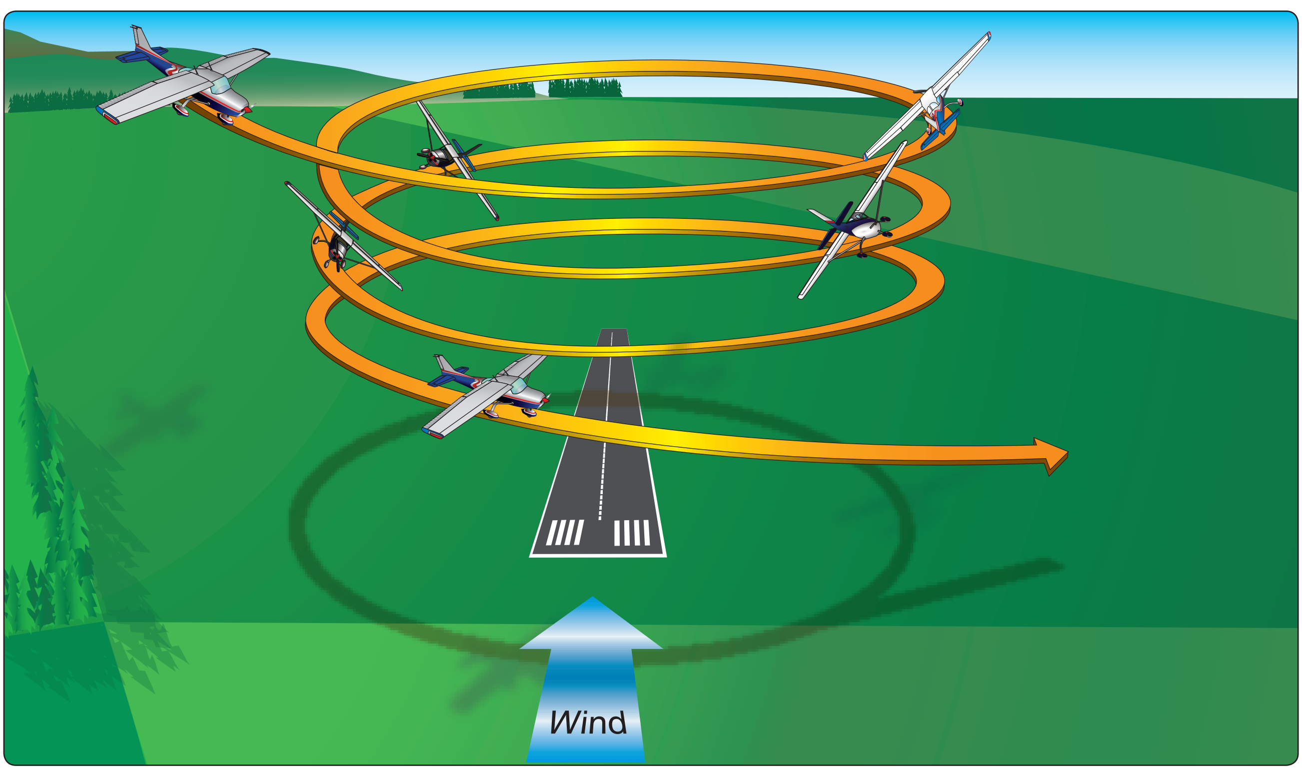

Figure 9-2. *Steep spiral.*

maneuver. During practice of the maneuver, the pilot should execute three turns and roll out toward a definite object or on a specific heading. During rollout, the smooth and accurate application of the flight controls allow the airplane to recover to a wing's level glide with no change in airspeed. Recovering to normal cruise flight would proceed after the establishment of a wing's level glide.

Common errors when performing steep spirals are:

- Not clearing the area
- Inadequate pitch control on entry or rollout
- Gaining altitude
- Not correcting the bank angle to compensate for wind
- Poor flight control coordination
- Ineffective use of trim
- Inadequate airspeed control
- Becoming disoriented
- Performing by reference to the flight instrument rather than visual references
- Not scanning for other traffic during the maneuver
- Not completing the turn on designated heading or reference

Chandelle

A chandelle is a maximum performance, 180° climbing turn that begins from approximately straight-and-level flight and concludes with the airplane in a wings-level, nose-high attitude just above stall speed. *[Figure 9-3]* The goal is to gain the most altitude possible for a given bank angle and power setting; however, the standard used to judge the maneuver is not the amount of altitude gained, but by the pilot's proficiency as it pertains to maximizing climb performance for the power and bank selected, as well as the skill demonstrated.

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 changing pitch; and the second 90° as constant pitch and changing bank. During the first 90°, the pilot will set the bank angle, increase power and pitch at a rate so that maximum pitch-up is set at the completion of the first 90°. If the pitch is not correct, the airplane's airspeed is either above stall speed or the airplane may aerodynamically stall prior to the completion of the maneuver. Starting at the 90° point, 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 while maintaining the constant pitch attitude set in the first 90°. If the rate of rollout is too rapid or sluggish, the airplane either does not

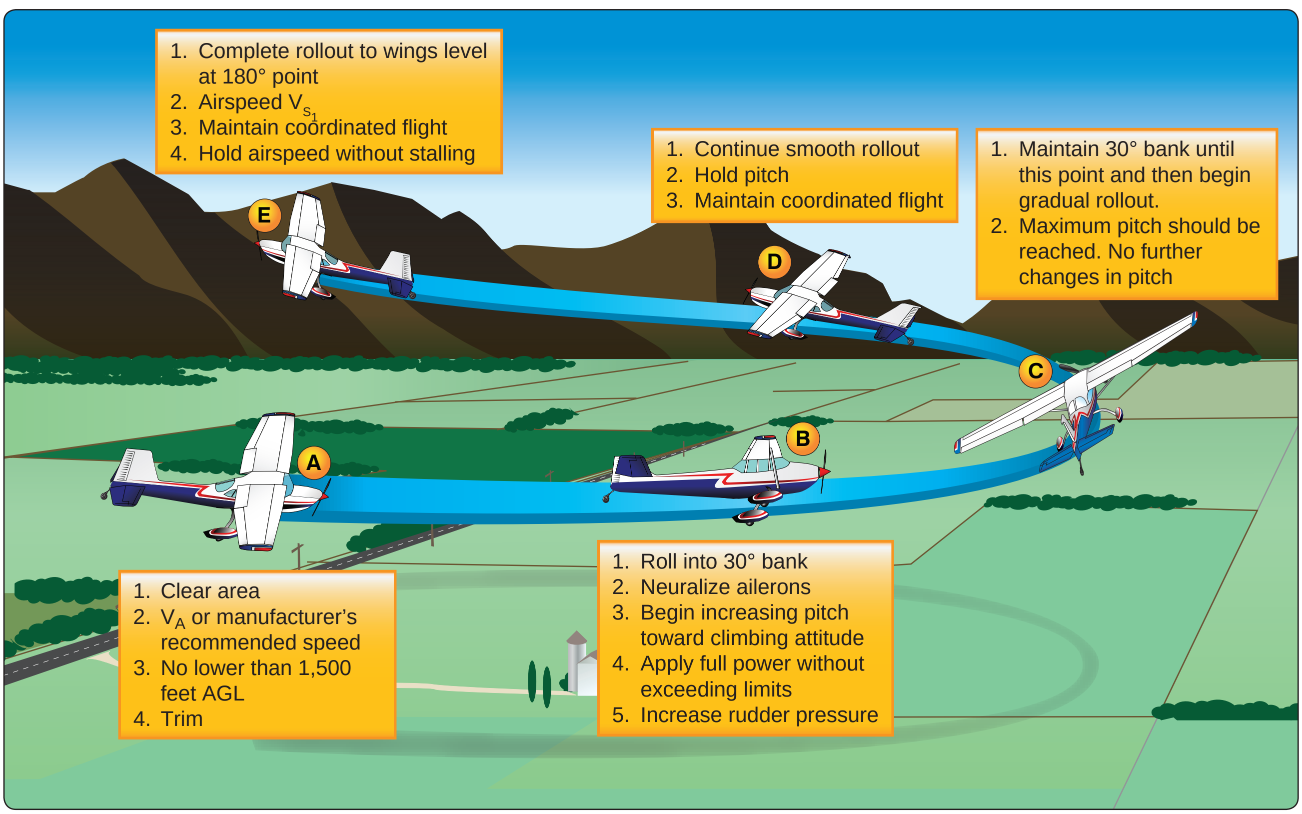

Figure 9-3. *Chandelle.*

complete or exceeds the 180° turn as the wings come level to the horizon.

Prior to starting the chandelle, the flaps and landing gear (if retractable) should be in the UP position. The chandelle is initiated by properly clearing the airspace for air traffic and hazards. The maneuver should be entered from straight-and-level flight or a shallow dive at an airspeed recommended by the manufacturer—in most cases this is the airplane's design maneuvering speed (V_A). *[Figure 9-3A]* After the appropriate entry airspeed has been established, the chandelle is started by smoothly entering a coordinated turn to the desired angle of bank; once the bank angle is established, which is generally 30°, a climbing turn should be started by smoothly applying elevator back pressure at a constant rate while simultaneously increasing engine power to the recommended setting. In airplanes with a fixed-pitch propeller, the throttle should be set so as to not exceed rotations per minute (rpm) limitations; in airplanes with constant-speed propellers, power may be set at the normal cruise or climb setting as appropriate. *[Figure 9-3B]*

Since the airspeed is constantly decreasing throughout the chandelle, the effects of left turning tendencies, such as P-factor, becomes more apparent. As airspeed decreases, right-rudder pressure is progressively increased to ensure that the airplane remains in coordinated flight. The pilot should maintain coordinated flight by sensing slipping or skidding pressures applied to the controls and by quick glances to the ball in the turn-and-slip or turn coordinator.

At the 90° point, the pilot should begin to smoothly roll out of the bank at a constant rate while maintaining the pitch attitude set in the first 90°. While the angle of bank is fixed during the first 90°, recall that as airspeed decreases, the overbanking tendency increases. *[Figure 9-3C]* As a result, proper use of the ailerons allows the bank to remain at a fixed angle until rollout is begun at the start of the final 90°. As the rollout continues, the vertical component of lift increases; therefore, a slight release of elevator back pressure is required to keep the pitch attitude from increasing.

When the airspeed is slowest, near the completion of the chandelle, right rudder pressure is significant, especially when rolling out from a left chandelle due to left adverse yaw and left turning tendencies, such as P-factor. *[Figure 9-3D]* When rolling out from a right chandelle, the yawing moment is to the right, which partially cancels some of the left turning tendency's effect. Depending on the airplane, either very little left rudder or a reduction in right rudder pressure is required during the rollout from a right chandelle. At the completion of 180° of turn, the wings should be leveled to the horizon, the airspeed should be just above stall speed, and the airplane's pitch high attitude should be held momentarily. *[Figure 9-3E]* Once demonstrated that the airplane is in controlled flight, the pitch attitude may be reduced and the airplane returned to straight-and-level cruise flight.

Common errors when performing chandelles are:

- Not clearing the area
- Initial bank is too shallow resulting in a stall
- Initial bank is too steep resulting in failure to gain maximum performance
- Allowing the bank angle to increase after initial establishment
- Not starting the recovery at the 90° point in the turn
- Allowing the pitch attitude to increase as the bank is rolled out during the second 90° of turn
- Leveling the wings prior to the 180° point being reached
- Pitch attitude is low on recovery resulting in airspeed well above stall speed
- Application of flight control pressures is not smooth
- Poor flight control coordination
- Stalling at any point during the maneuver
- Execution of a steep turn instead of a climbing maneuver
- Not scanning for other traffic during the maneuver
- Performing by reference to the flight instrument rather than visual references

Lazy Eight

The lazy eight is a maneuver that is designed to develop the proper coordination of the flight controls across a wide range of airspeeds and attitudes. It is the only standard flight training maneuver that, at no time, flight control pressures are constant. In an attempt to simplify the discussion about this maneuver, the lazy eight can be loosely described by the ground reference maneuver, S-turns across the road. Recall that S-turns across the road are made of opposing 180° turns. For example, first a 180° turn to the right, followed immediately by a 180° turn to the left. The lazy eight adds both a climb and descent to each 180° segment. The first 90° is a climb; the second 90° is a descent. *[Figure 9-4]*

To aid in the performance of the lazy eight's symmetrical climbing/descending turns, prominent reference points must be selected on the natural horizon. The reference points selected should be at 45°, 90°, and 135° from the direction in which the maneuver is started for each 180° turn. With the general concept of climbing and descending turns grasped, specifics of the lazy eight can then be discussed.

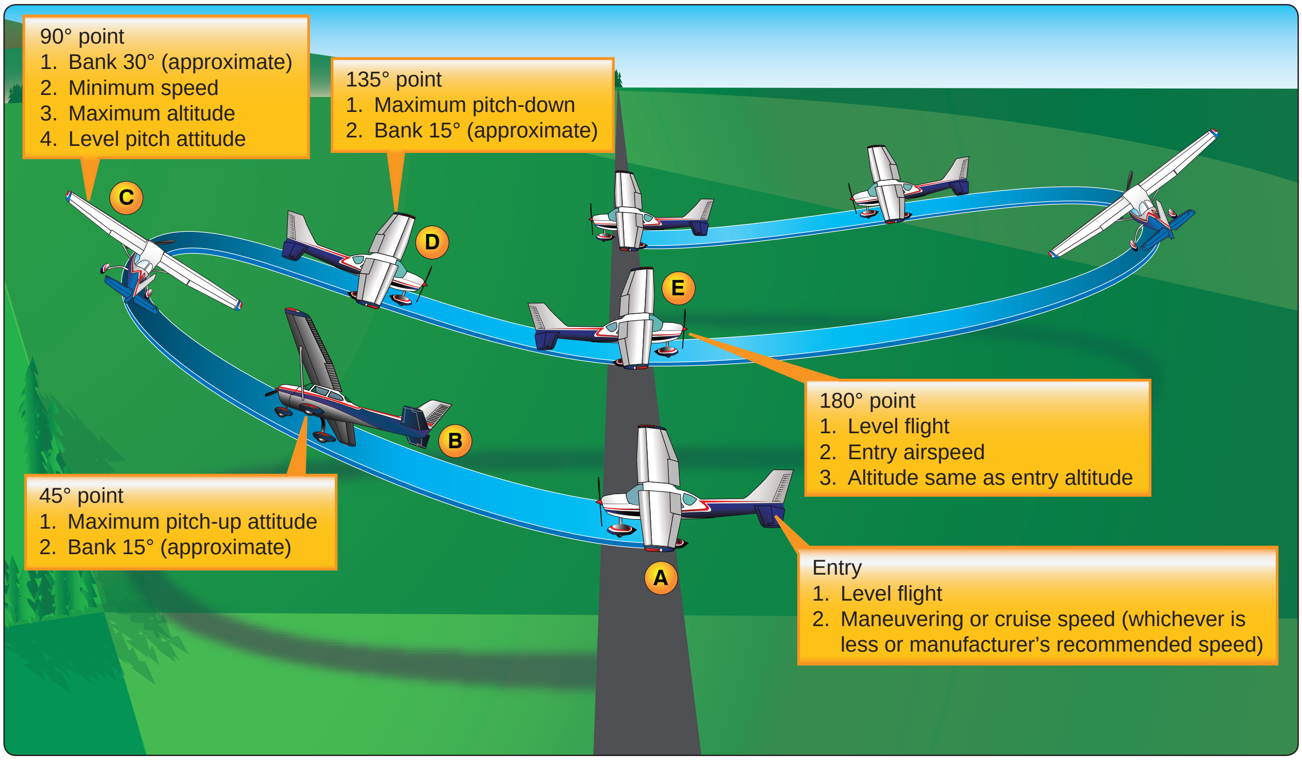

Figure 9-4. *Lazy eight.*

Shown in *Figure 9-4A*, from level flight a gradual climbing turn is begun in the direction of the 45° reference point; the climbing turn should be planned and controlled so that the maximum pitch-up attitude is reached at the 45° point with an approximate bank angle of 15°. *[Figure 9-4B]* As the pitch attitude is raised, the airspeed decreases, which causes the rate of turn to increase. As such, the lazy eight must begin with a slow rate of roll as the combination of increasing pitch and increasing bank may cause the rate of turn to be so rapid that the 45° reference point will be reached before the highest pitch attitude is attained. At the 45° reference point, the pitch attitude should be at the maximum pitch-up selected for the maneuver while the bank angle is slowly increasing. Beyond the 45° reference point, the pitch-up attitude should begin to decrease slowly toward the horizon until the 90° reference point is reached where the pitch attitude should be momentarily level.

The lazy eight requires substantial skill in coordinating the aileron and rudder; therefore, some discussion about coordination is warranted. As pilots understand, the purpose of the rudder is to maintain coordination; slipping or skidding is to be avoided. Pilots should remember that since the airspeed is still decreasing as the airplane is climbing; additional right rudder pressure must be applied to counteract left turning tendencies, such as P-factor. As the airspeed decreases, right rudder pressure must be gradually applied to counteract yaw at the apex of the lazy eight in both the right and left turns; however, additional right rudder pressure is required when turning or rolling out to the right than left because left adverse yaw augments with the left yawing P-factor in an attempt to yaw the nose to the left. Correction is needed to prevent these additive left yawing moments from decreasing a right turn's rate. In contrast, in left climbing turns or rolling to the left, the left yawing P-factor tends to cancel the effects of adverse yaw to the right; consequently, less right rudder pressure is required. These concepts can be difficult to remember; however, to simplify, rolling right at low airspeeds and high-power settings requires substantial right rudder pressures.

At the lazy eight's 90° reference point, the bank angle should also have reached its maximum angle of approximately 30°. *[Figure 9-4C]* The airspeed should be at its minimum, just about 5 to 10 knots above stall speed, with the airplane's pitch attitude passing through level flight. Coordinated flight at this point requires that, in some flight conditions, a slight amount of opposite aileron pressure may be required to prevent the wings from overbanking while maintaining rudder pressure to cancel the effects of left turning tendencies.

The pilot should not hesitate at the 90° point but should continue to maneuver the airplane into a descending turn. The rollout from the bank should proceed slowly while the airplane's pitch attitude is allowed to decrease. When the airplane has turned 135°, the airplane should be in its lowest pitch attitude. *[Figure 9-4D]* Pilots should remember that the airplane's airspeed is increasing as the airplane's pitch attitude decreases; therefore, to maintain proper coordination will require a decrease in right rudder pressure. As the airplane approaches the 180° point, it is necessary to progressively relax rudder and aileron pressure while simultaneously raising pitch and roll to level flight. As the rollout is being accomplished, the pilot should note the amount of turn remaining and adjust the rate of rollout and pitch change so that the wings and nose are level at the original airspeed just as the 180° point is reached.

Upon arriving at 180° point, a climbing turn should be started immediately in the opposite direction toward the preselected reference points to complete the second half of the lazy eight in the same manner as the first half. *[Figure 9-4E]*

Power should be set so as not to enter the maneuver at an airspeed that would exceed manufacturer's recommendations, which is generally no greater than V_A. Power and bank angle have significant effect on the altitude gained or lost; if excess power is used for a given bank angle, altitude is gained at the completion of the maneuver; however, if insufficient power is used for a given bank angle, altitude is lost.

Common errors when performing lazy eights are:

- Not clearing the area
- Maneuver is not symmetrical across each 180°
- Inadequate or improper selection or use of 45°, 90°, 135° references
- Ineffective planning
- Gain or loss of altitude at each 180° point
- Poor control at the top of each climb segment resulting in the pitch rapidly falling through the horizon
- Airspeed or bank angle standards not met
- Control roughness
- Poor flight control coordination
- Stalling at any point during the maneuver
- Execution of a steep turn instead of a climbing maneuver
- Not scanning for other traffic during the maneuver
- Performing by reference to the flight instrument rather than visual references

Chapter Summary

Performance maneuvers are used to develop a pilot's skills in coordinating the flight control's use and effect while enhancing the pilot's ability to divide attention across the various demands of flight. Performance maneuvers are also designed to further develop a pilot's application and correlation of the fundamentals of flight and integrate developing skills into advanced maneuvers. Developing highly-honed skills in performance maneuvers allows the pilot to effectively progress toward the mastery of flight. Mastery is developed as the mechanics of flight become a subconscious, rather than a conscious, application of the flight controls to maneuver the airplane in attitude, orientation, and position.

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Airplane Flying Handbook

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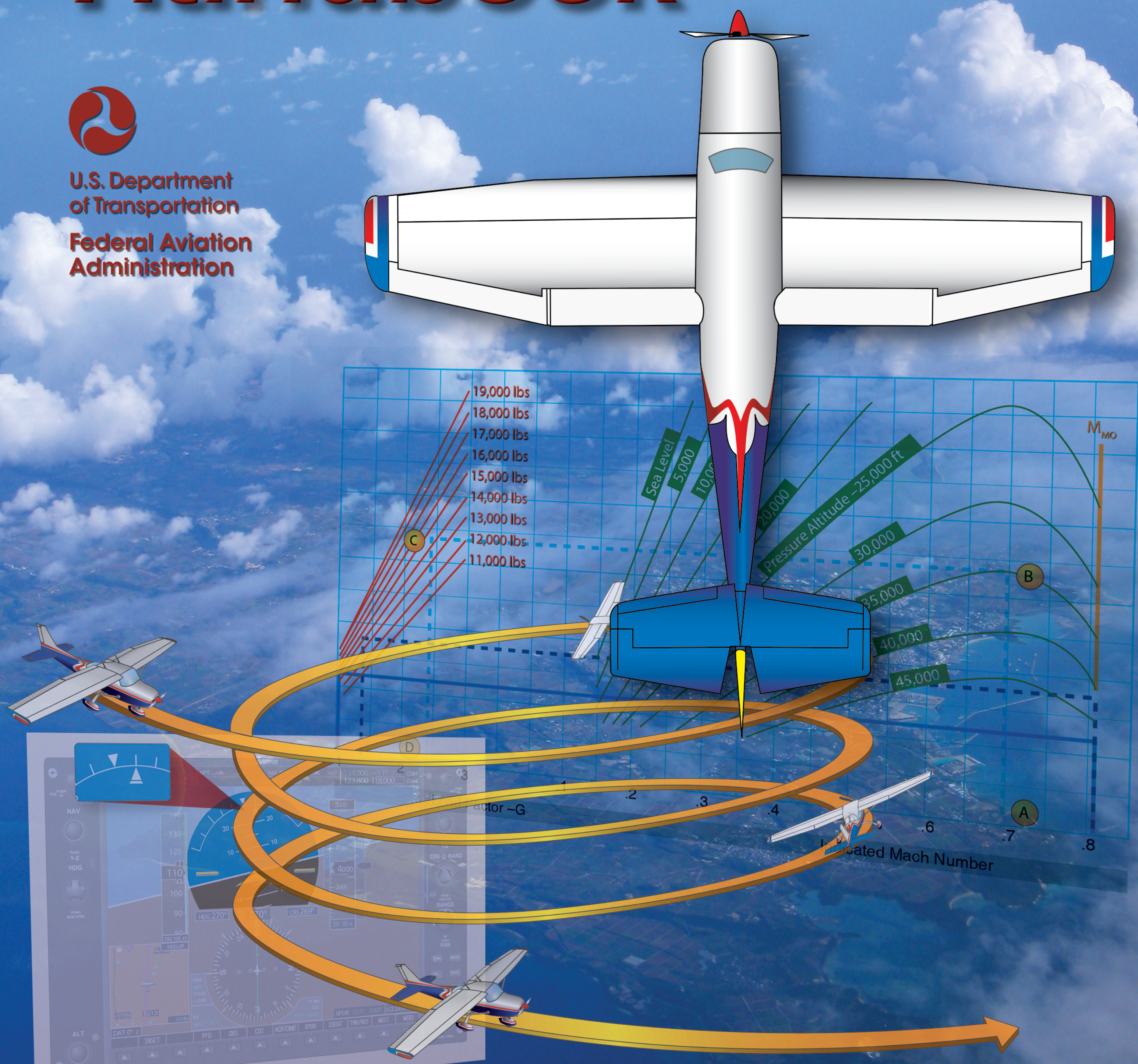

Airplane Flying Handbook

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The rollout from the steep turn should be timed so that the wings reach level flight when the airplane is on the heading from which the maneuver was started. A good rule of thumb is to begin the rollout at ½ the number of degrees of bank prior to reaching the terminating heading. For example, if a right steep turn was begun on a heading of 270° and if the bank angle is 60°, the pilot should begin the rollout 30° prior or at a heading of 240°. While the rollout is being made, elevator back pressure, trim (if used), and power should be gradually reduced, as necessary, to maintain the altitude and airspeed.

Common errors when performing steep turns are:

1. Not clearing the area
2. Inadequate pitch control on entry or rollout
3. Gaining or losing altitude
4. Failure to maintain constant bank angle
5. Poor flight control coordination
6. Ineffective use of trim
7. Ineffective use of power
8. Inadequate airspeed control
9. Becoming disoriented
10. Performing by reference to the flight instruments rather than visual references
11. Failure to scan for other traffic during the maneuver
12. Attempting to start recovery prematurely
13. Failure to stop the turn on the designated heading

Steep Spiral

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. This maneuver may be useful during an emergency landing. A steep spiral is a gliding turn wherein the pilot maintains a constant radius around a surface-based reference point—similar to the turns around a point maneuver, but in this case the airplane is rapidly descending. The maneuver consists of the completion of at least three 360° turns *[Figure 10-2]*, and should begin at sufficient altitude such that the maneuver concludes no lower than 1,500 feet above ground level (AGL). Note that while there are similarities between a steep spiral and an emergency descent, the reasons for using the two maneuvers may differ, and the airspeed and configuration are usually different.

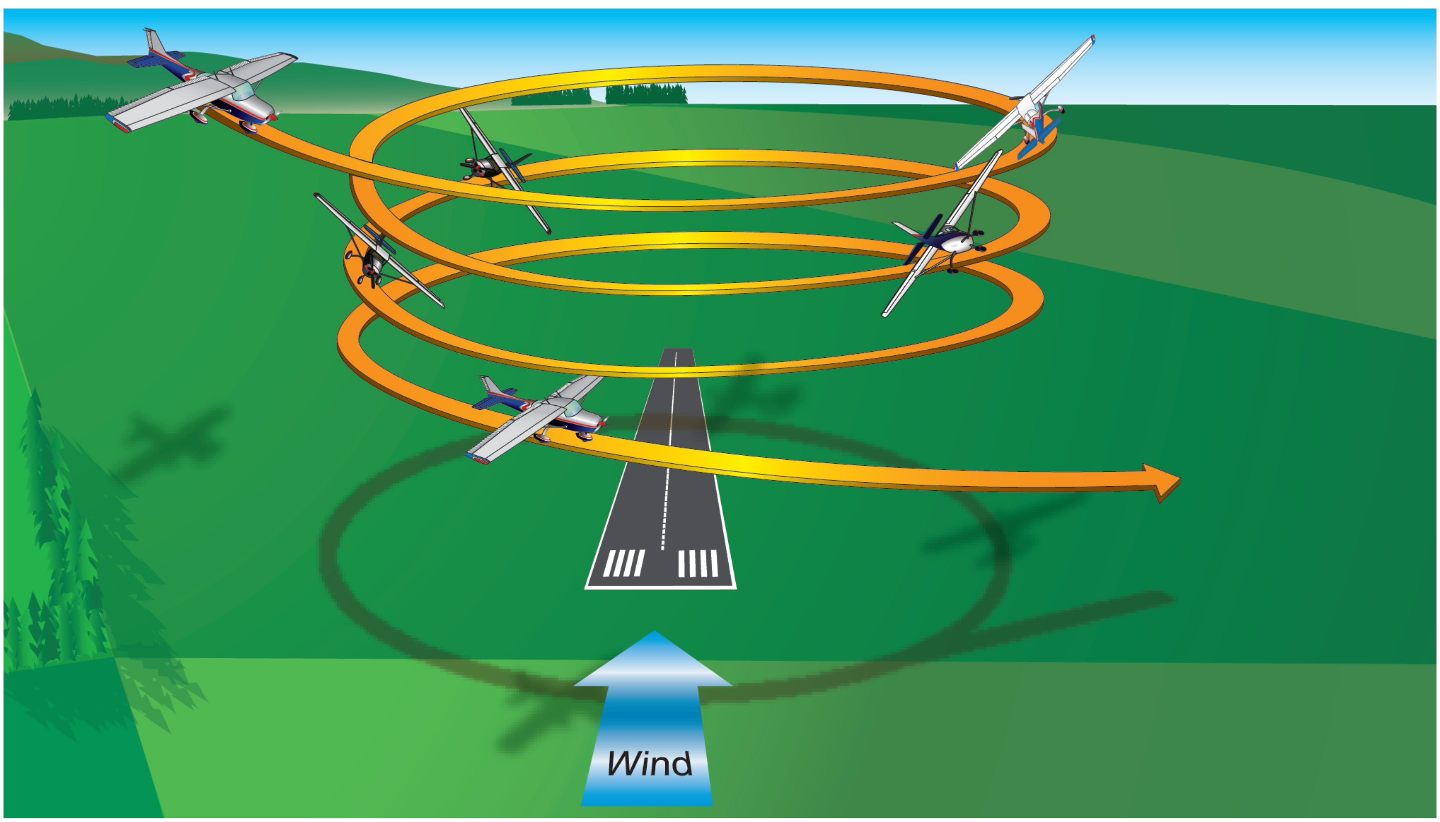

Figure 10-2. *Steep spiral.*

The steep spiral is initiated by properly clearing the airspace for air traffic and hazards. In general, the throttle is closed to idle, carburetor heat is applied if equipped, and gliding speed is established. Once the proper airspeed is attained, the pitch should be lowered and the airplane rolled to the desired bank angle as the reference point is reached. The pilot should consider the distance from the reference point since that establishes the turning radius, and the steepest bank should not exceed 60°. The gliding spiral should be a turn of constant radius while maintaining the airplane's position relative to the reference. This can only be accomplished by proper correction for wind drift by steepening the bank on downwind headings and shallowing the bank on upwind headings. During the steep spiral, the pilot should continually correct for any changes in wind direction and velocity to maintain a constant radius.

Operating the engine at idle speed for any prolonged period during the glide may result in excessive engine cooling, spark plug fouling, or carburetor ice. To assist in avoiding these issues, the throttle should be periodically advanced and sustained for a few seconds. Monitoring cylinder head temperature gauges, if available, provides a pilot with additional information on engine cooling. When advancing the throttle, the pitch attitude should be adjusted to maintain a constant airspeed and, preferably, this should be done when headed into the wind.

Maintaining a constant airspeed throughout the maneuver is an important skill for a pilot to develop. This is necessary because the airspeed tends to fluctuate as the bank angle is changed throughout the maneuver. The pilot should anticipate pitch corrections as the bank angle is varied throughout the maneuver. During practice of the maneuver, the pilot should execute at least three turns and roll out toward a definite object or on a specific heading. To make the exercise more challenging, the pilot rolls out on a heading perpendicular to or directly into the wind rather toward a specific object. This ability would be a particularly useful skill in the event of an actual emergency. In addition, noting the altitude lost during each revolution would help the pilot determine when to roll out in an actual emergency so as not to be too high or too low to make a safe approach. During rollout, the smooth and accurate application of the flight controls allow the airplane to recover to a wings-level glide with no change in airspeed. Recovering to normal cruise flight would proceed after the establishment of a wings-level glide.

Common errors when performing steep spirals are:

1. Not clearing the area
2. Inadequate pitch control on entry or rollout
3. Not correcting the bank angle to compensate for wind
4. Poor flight control coordination
5. Ineffective use of trim
6. Inadequate airspeed control
7. Becoming disoriented
8. Performing by reference to the flight instruments rather than visual references
9. Not scanning for other traffic during the maneuver
10. Not completing the turn on the designated heading or reference

Chandelle

A chandelle is a maximum performance, 180° climbing turn that begins from approximately straight-and-level flight and concludes with the airplane in a wings-level, nose-high attitude just above stall speed. *[Figure 10-3]* The goal is to gain the most altitude possible for a given bank angle and power setting; however, the standard used to judge the maneuver is not the amount of altitude gained, but rather the pilot's proficiency as it pertains to maximizing climb performance for the power and bank selected, as well as the skill demonstrated.

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.

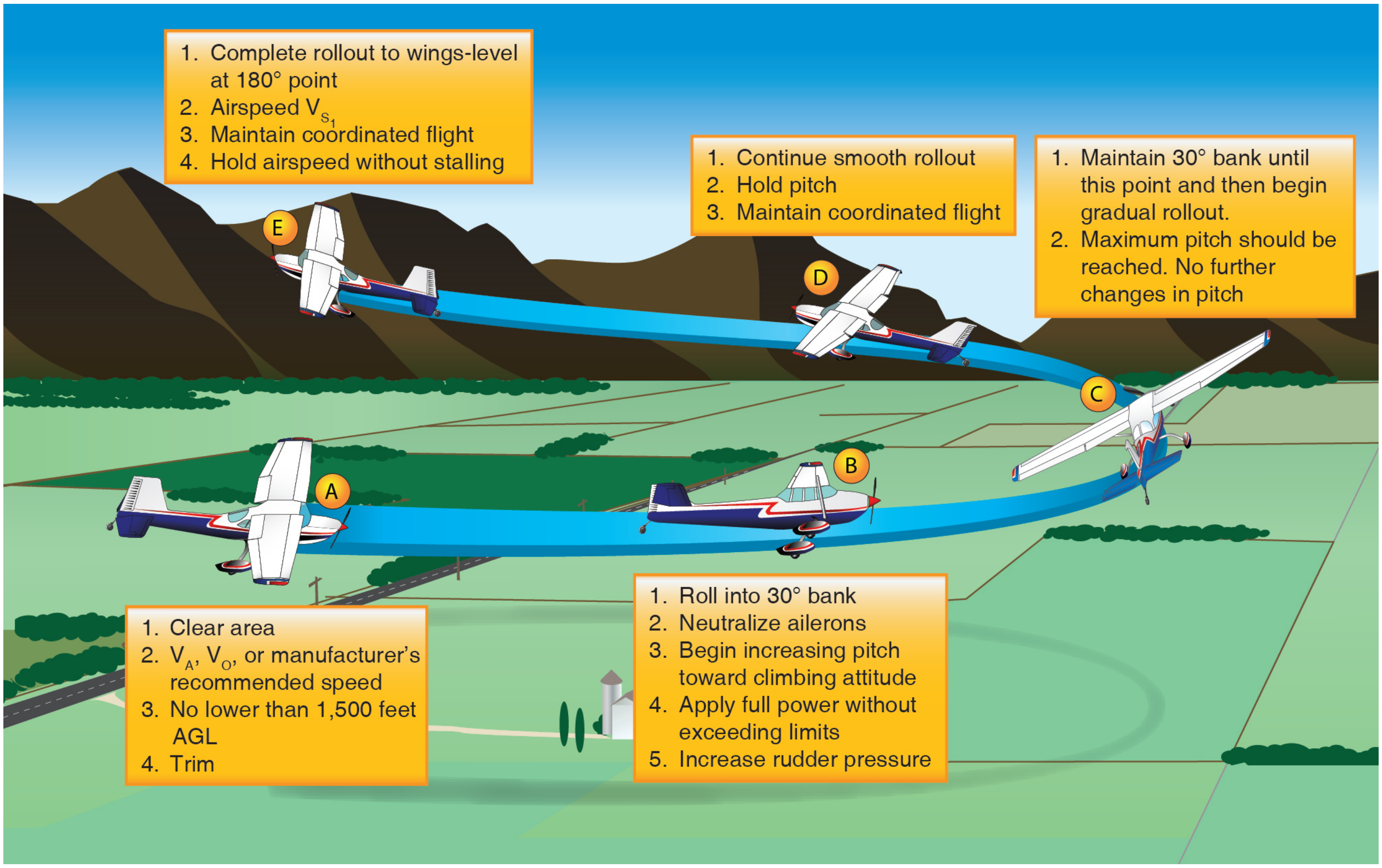

Figure 10-3. *Chandelle.*

Prior to starting the chandelle, the flaps and landing gear (if retractable) should be in the UP position. The chandelle is initiated by properly clearing the airspace for air traffic and hazards. The maneuver should be entered from straight-and-level flight or a shallow dive at an airspeed recommended by the manufacturer—in many cases this is the airplane's design maneuvering speed (V_A) or operating maneuvering speed (V_O). *[Figure 10-3A]* After the appropriate entry airspeed has been established, the chandelle is started by smoothly entering a coordinated turn to the desired angle of bank. Once the bank angle is established, which is generally 30°, a climbing turn should be started by smoothly applying elevator back pressure at a constant rate while simultaneously increasing engine power to the recommended setting. In airplanes with a fixed-pitch propeller, the throttle should be set so as to not exceed rotations per minute (rpm) limitations. In airplanes with constant-speed propellers, power may be set at the normal cruise or climb setting as appropriate. *[Figure 10-3B]*

As airspeed decreases during the chandelle, left-turning tendencies, such as P-factor, have greater effect. As airspeed decreases, right rudder pressure is progressively increased to ensure that the airplane remains in coordinated flight. The pilot maintains coordinated flight by sensing physical slipping or skidding, by glancing at the ball in the turn-and-slip or turn coordinator, and by using appropriate control pressures.

At the 90° point, the pilot should begin to smoothly roll out of the bank at a constant rate while maintaining the pitch attitude attained at the end of the first 90°. While the angle of bank is fixed during the first 90°, recall that as airspeed decreases, the overbanking tendency increases. *[Figure 10-3C]* As a result, proper use of the ailerons allows the bank to remain at a fixed angle until rollout is begun at the start of the final 90°. As the rollout continues, the vertical component of lift increases. However, as speed continues to decrease, a slight increase of elevator back pressure is required to keep the pitch attitude from decreasing.

When the airspeed is slowest, near the completion of the chandelle, right rudder pressure is significant, especially when rolling out from a left chandelle due to left adverse yaw and left-turning tendencies, such as P-factor. *[Figure 10-3D]* When rolling out from a right chandelle, the yawing moment is to the right, which partially cancels some of the left-turning tendency's effect. Depending on the airplane, either very little left rudder or a reduction in right rudder pressure is required during the rollout from a right chandelle. At the completion of 180° of turn, the wings should be level to the horizon, the airspeed should be just above the power-on stall speed, and the airplane's pitch-high attitude should be held momentarily. *[Figure 10-3E]*

Once the airplane is in controlled flight, the pitch attitude may be reduced and the airplane returned to straight-and-level cruise flight.

Common errors when performing chandelles are:

1. Not clearing the area
2. Initial bank is too shallow resulting in a stall
3. Initial bank is too steep resulting in failure to gain maximum performance
4. Allowing the bank angle to increase after initial establishment
5. Not starting the recovery at the 90° point in the turn
6. Allowing the pitch attitude to increase as the bank is rolled out during the second 90° of turn
7. Leveling the wings prior to the 180° point being reached
8. Pitch attitude is low on recovery resulting in airspeed well above stall speed
9. Application of flight control pressures is not smooth
10. Poor flight control coordination
11. Stalling at any point during the maneuver
12. Execution of a steep turn instead of a climbing maneuver
13. Not scanning for other traffic during the maneuver
14. Performing by reference to the instruments rather than visual references

Lazy Eight

The lazy eight is a maneuver that is designed to develop the proper coordination of the flight controls across a wide range of airspeeds and attitudes. It is the only standard flight training maneuver in which flight control pressures are constantly changing. In an attempt to simplify the discussion about this maneuver, the lazy eight can be loosely compared to the ground reference maneuver, S-turns across the road. Recall that S-turns across the road are made of opposing 180° turns. For example, first a 180° turn to the right, followed immediately by a 180° turn to the left. The lazy eight adds both a climb and descent to each 180° segment. The first 90° is a climb; the second 90° is a descent. *[Figure 10-4]*

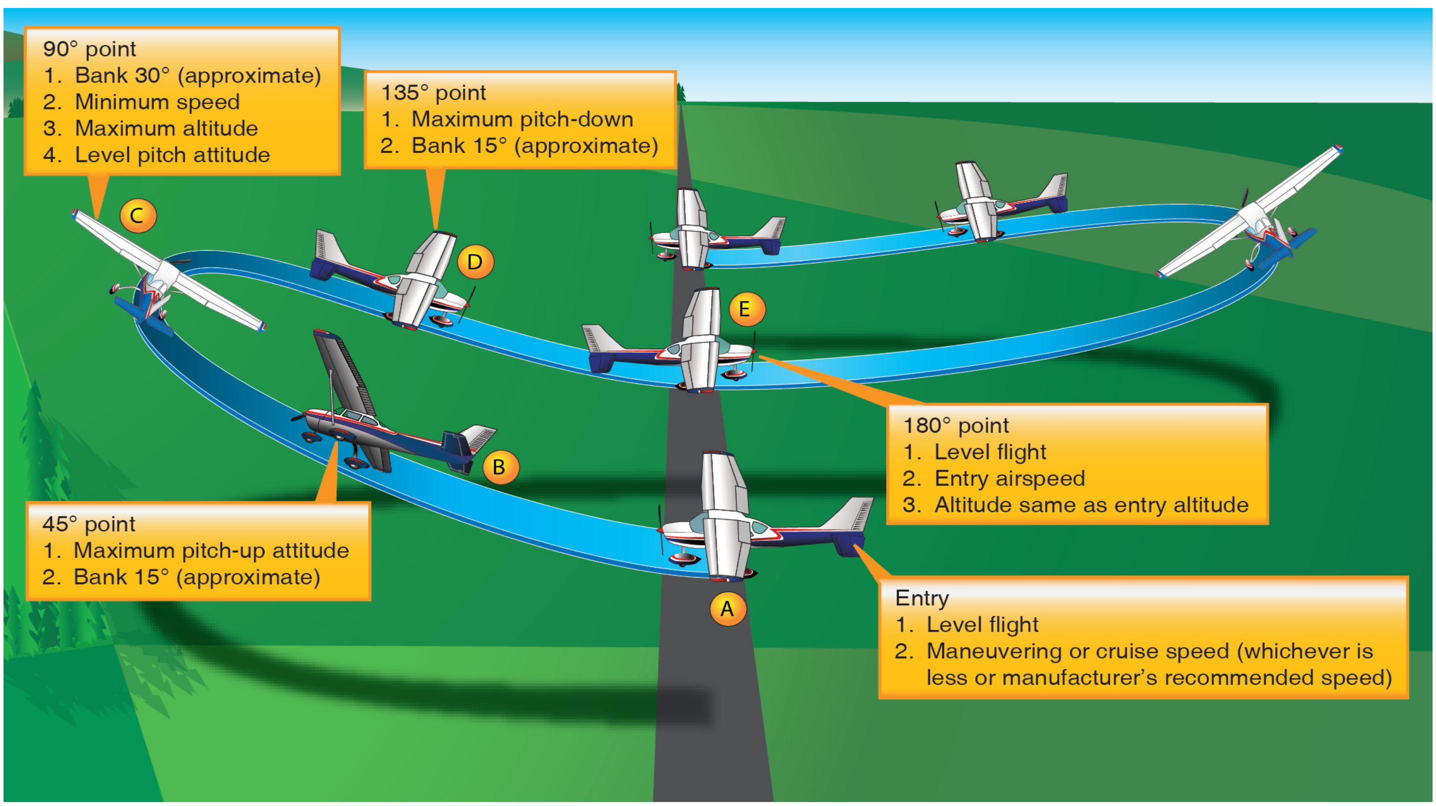

Figure 10-4. *Lazy eight.*

The previous description of a lazy eight and *figure 10-4* describe how a lazy eight looks from outside the flight deck and describes it as two 180° turns with altitude changes. How does it look from the pilot's perspective? Think of the longitudinal axis of the airplane as a pencil, which draws on whatever it points to. During this maneuver, the longitudinal axis of the airplane traces a symmetrical eight on its side with segments of the eight above and below the horizon, and it takes both 180° turns to form both loops of an eight. The first 90° of the first 180° turn traces the upper portion of one of the loops. The second 90° portion of the second 180° turn traces the lower portion of that loop at the end of the maneuvuer. The second 90° of the first 180° turn and the first 90° of the second 180° turn complete the other loop of the eight. The sensation of using the airplane to slowly draw this symbol gives the maneuver its name.

To aid in the performance of the lazy eight's symmetrical climbing/descending turns, the pilot selects prominent reference points on the natural horizon. The reference points selected should be at 45°, 90°, and 135° from the direction in which the maneuver is started for each 180° turn. With the general concept of climbing and descending turns grasped, specifics of the lazy eight can then be discussed.

Shown in *Figure 10-4A*, from level flight a gradual climbing turn is begun in the direction of the 45° reference point. The climbing turn should be planned and controlled so that the maximum pitch-up attitude is reached at the 45° point with an approximate bank angle of 15°. *[Figure 10-4B]* As the pitch attitude is raised, the airspeed decreases, which causes the rate of turn to increase. As such, the lazy eight should begin with a slow rate of roll as the combination of increasing pitch and increasing bank may cause the rate of turn to be so rapid that the 45° reference point will be reached before the highest pitch attitude is attained. At the 45° reference point, the pitch attitude should be at the maximum pitch-up selected for the maneuver while the bank angle is slowly increasing. Beyond the 45° reference point, the pitch-up attitude should begin to decrease slowly toward the horizon until the 90° reference point is reached where the pitch attitude passes through level.

The lazy eight requires substantial skill in coordinating the aileron and rudder; therefore, some discussion about coordination is warranted. As pilots understand, the purpose of the rudder is to maintain coordination; slipping or skidding is to be avoided. Pilots should remember that since the airspeed is still decreasing as the airplane is climbing; additional right rudder pressure should be applied to counteract left-turning tendencies, such as P-factor. As the airspeed decreases, right rudder pressure should be gradually applied to counteract yaw at the apex of the lazy eight in both the right and left turns; however, additional right rudder pressure is required when using right aileron control pressure. When displacing the ailerons for more lift on the left wing, left adverse yaw augments with the left-yawing P-factor in an attempt to yaw the nose to the left. In contrast, in left climbing turns or rolling to the left, the left yawing P-factor tends to cancel the effects of adverse yaw to the right; consequently, less right rudder pressure is required. These concepts can be difficult to remember; however, to simplify, rolling right at low airspeeds and high-power settings requires substantial right rudder pressures.

At the lazy eight's 90° reference point, the bank angle should also have reached its maximum angle of approximately 30°. *[Figure 10-4C]* The airspeed should be at its minimum, just about 5 to 10 knots above stall speed, with the airplane's pitch attitude passing through level flight. Coordinated flight at this point requires that, in some flight conditions, a slight amount of opposite aileron pressure may be required to prevent the wings from overbanking while maintaining rudder pressure to cancel the effects of left-turning tendencies.

The pilot should not hesitate at the 90° point but should continue to maneuver the airplane into a descending turn. The rollout from the bank should proceed slowly while the airplane's pitch attitude is allowed to decrease. When the airplane has turned 135°, the airplane should be in its lowest pitch attitude. *[Figure 10-4D]* Pilots should remember that the airplane's airspeed is increasing as the airplane's pitch attitude decreases; therefore, maintaining proper coordination will require a decrease in right rudder pressure. As the airplane approaches the 180° point, it is necessary to progressively relax rudder and aileron pressure while simultaneously raising pitch and roll to level flight. As the rollout is being accomplished, the pilot should note the amount of turn remaining and adjust the rate of rollout and pitch change so that the wings and nose are level at the original airspeed just as the 180° point is reached.

Upon arriving at 180° point, a climbing turn should be started immediately in the opposite direction toward the preselected reference points to complete the second half of the lazy eight in the same manner as the first half. *[Figure 10-4E]*

Power should be set so as not to enter the maneuver at an airspeed that would exceed manufacturer's recommendations, which is generally no greater than V_A or V_O. Power and bank angle have significant effect on the altitude gained or lost; if excess power is used for a given bank angle, altitude is gained at the completion of the maneuver; however, if insufficient power is used for a given bank angle, altitude is lost.

Common errors when performing lazy eights are:

1. Not clearing the area
2. Maneuver is not symmetrical across each 180°
3. Inadequate or improper selection or use of 45°, 90°, 135° references
4. Ineffective planning
5. Gain or loss of altitude at each 180° point
6. Poor control at the top of each climb segment resulting in the pitch rapidly falling through the horizon
7. Airspeed or bank angle standards not met
8. Control roughness
9. Poor flight control coordination
10. Stalling at any point during the maneuver
11. Execution of a steep turn instead of a climbing maneuver
12. Not scanning for other traffic during the maneuver
13. Performing by reference to the flight instruments rather than visual references

Chapter Summary

Performance maneuvers are used to develop a pilot's skills in coordinating the flight control's use and effect while enhancing the pilot's ability to divide attention across the various demands of flight. Performance maneuvers are also designed to further develop a pilot's application and correlation of the fundamentals of flight and integrate developing skills into advanced maneuvers. Developing highly-honed skills in performance maneuvers allows the pilot to effectively progress toward the mastery of flight. Mastery is developed as the mechanics of flight become a subconscious, rather than a conscious, application of the flight controls to maneuver the airplane in attitude, orientation, and position.