Turn Radius

To understand the relationship between airspeed, bank, and radius of turn, it should be noted that the rate of turn at any given true airspeed depends on the horizontal lift component. The horizontal lift component varies in proportion to the amount of bank. Therefore, the rate of turn at a given airspeed increases as the angle of bank is increased. On the other hand, when a turn is made at a higher airspeed at a given bank angle, the inertia is greater and the horizontal lift component required for the turn is greater, causing the turning rate to become slower. *[Figure 3-14]* Therefore, at a given angle of bank, a higher airspeed makes the radius of turn larger because the airplane turns at a slower rate.

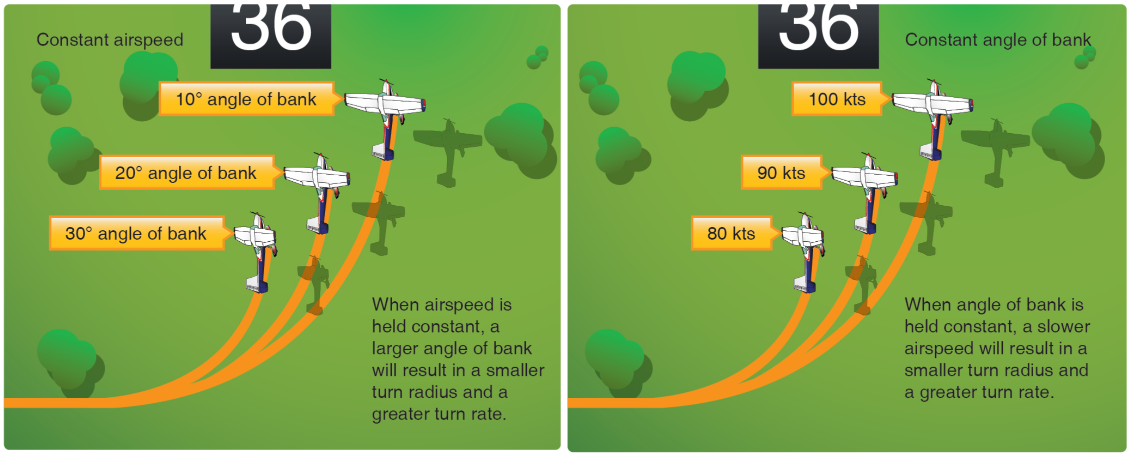

Figure 3-14. *Angle of bank and airspeed regulate rate and radius of turn.*

As the radius of the turn becomes smaller, a significant difference develops between the airspeed of the inside wing and the airspeed of the outside wing. The wing on the outside of the turn travels a longer path than the inside wing, yet both complete their respective paths in the same unit of time.

Therefore, the outside wing travels at a faster airspeed than the inside wing and, as a result, it develops more lift. This creates an overbanking tendency that needs to be controlled by the use of opposite aileron when the desired bank angle is reached. *[Figure 3-15]* Because the outboard wing is developing more lift, it also produces more drag. The drag causes a slight slip during steep turns that should be corrected by use of the rudder.

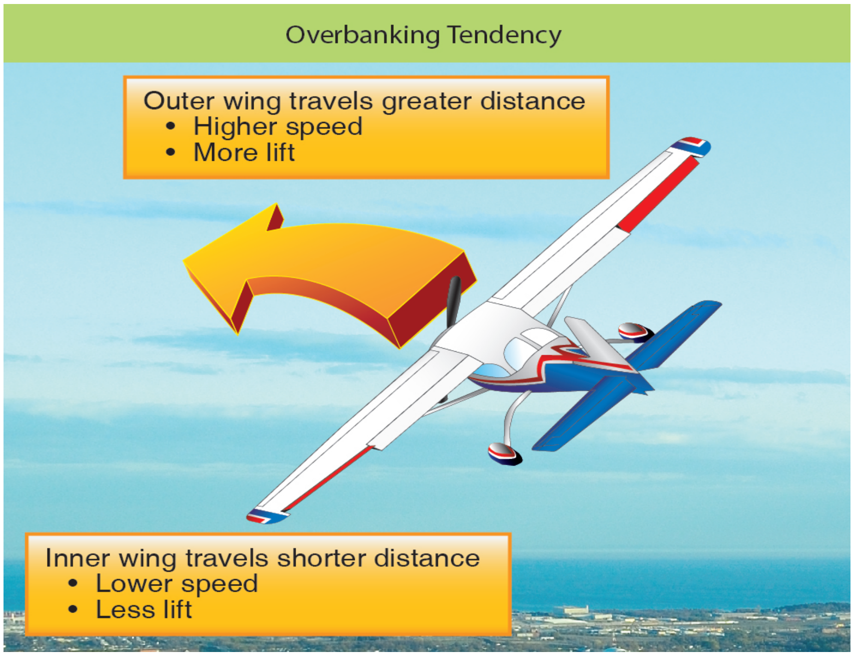

Figure 3-15. *Overbanking tendency.*

Establishing a Turn

On most light single-engine airplanes, the top surface of the engine cowling is fairly flat, and its horizontal surface to the natural horizon provides a reasonable indication for initially setting the degree of bank angle. *[Figure 3-16]* The pilot should then cross-check the flight instruments to verify that the correct bank angle has been achieved. Information obtained from the attitude indicator shows the angle of the wing in relation to the horizon.

Figure 3-16. *Visual reference for angle of bank.*

The pilot's seating position in the airplane is important as it affects the interpretation of outside visual references. A common problem is that a pilot may lean away from the turn in an attempt to remain in an upright position in relation to the horizon. This should be corrected immediately if the pilot is to properly learn to use visual references. *[Figure 3-17]*

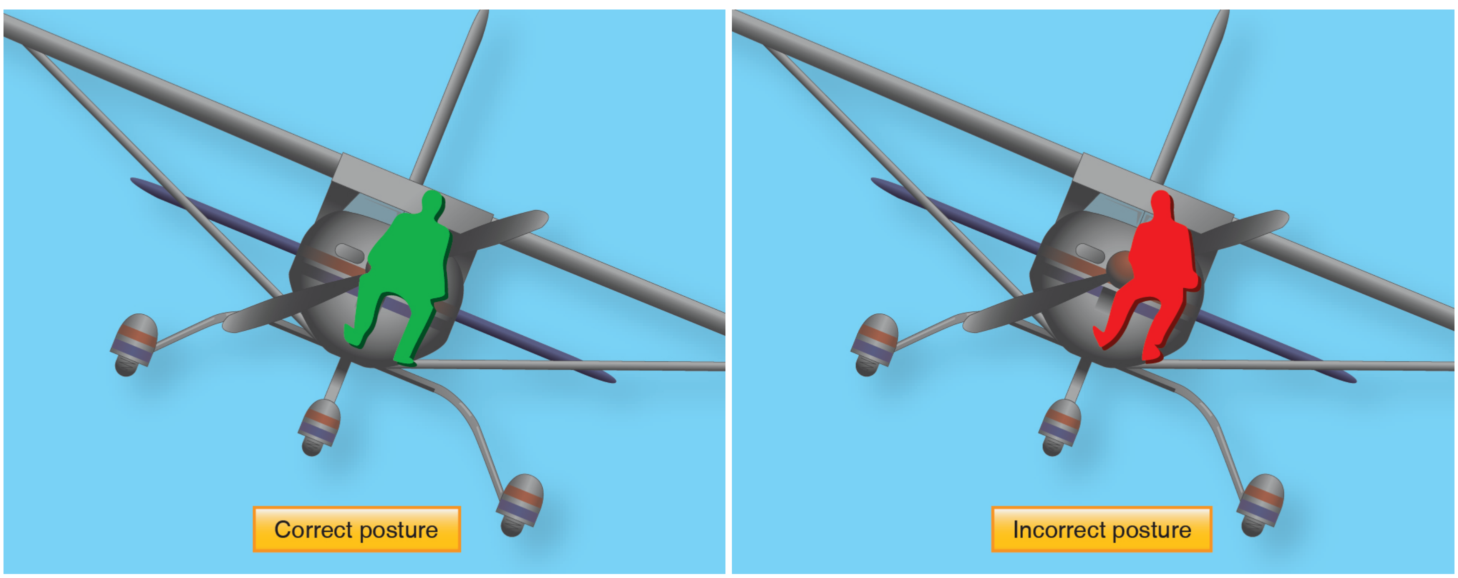

Figure 3-17. *Correct and incorrect posture while seated in the airplane.*

Because most airplanes have side-by-side seating, a pilot does not sit on the airplane's longitudinal axis, which is where the airplane rotates in roll. The pilot sits slightly off to one side, typically the left, of the longitudinal axis. Due to parallax error, this makes the nose of the airplane appear to rise when making a left turn (due to pilot lowering in relation to the longitudinal axis) and the nose of the airplane appear to descend when making right turns (due to pilot elevating in relation to the longitudinal axis). *[Figure 3-18]*

Beginning pilots should not use large aileron and rudder control inputs. This is because large control inputs produce rapid roll rates and allow little time for the pilot to evaluate and make corrections. Smaller flight control inputs result in slower roll rates and provide for more time to accurately complete the necessary pitch and bank corrections.

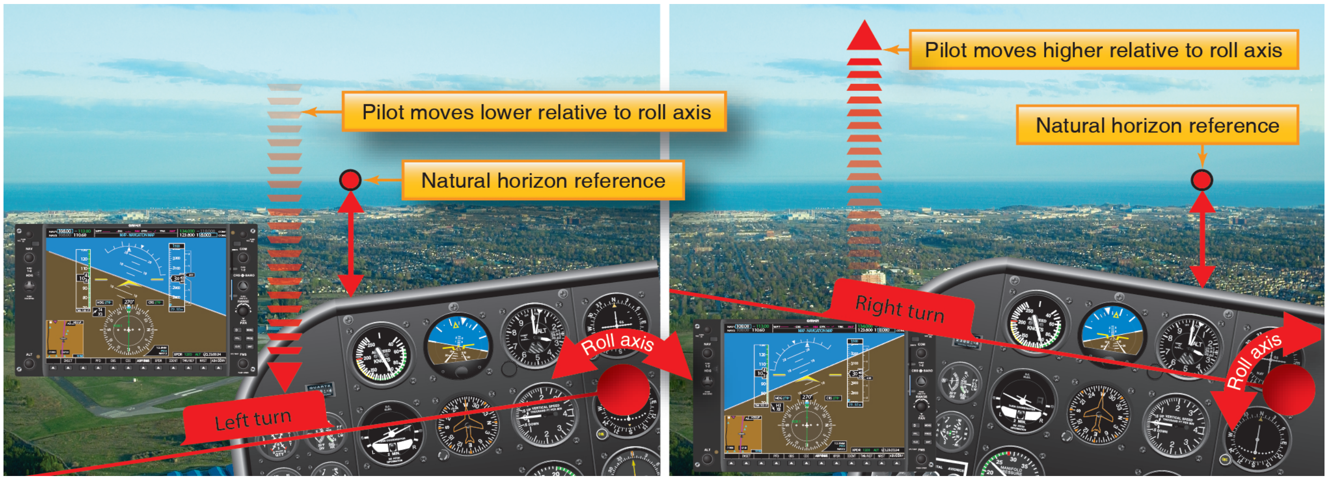

Figure 3-18. *Parallax view.*

Some additional considerations for initiating turns are the following:

- If the airplane's nose starts to move before the bank starts, the rudder is being applied too soon.
- If the bank starts before the nose starts turning or the nose moves in the opposite direction, the rudder is being applied too late.
- If the nose moves up or down when entering a bank, excessive or insufficient elevator back pressure is being applied.

After the bank has been established, all flight control pressures applied to the ailerons and rudder may be relaxed or adjusted, depending on the established bank angle, to compensate for the airplane's inherent stability or overbanking tendencies. The airplane should remain at the desired bank angle with the proper application of aileron pressure. If the desired bank angle is shallow, the pilot needs to maintain a small amount of aileron pressure into the direction of bank including rudder to compensate for yaw effects. For medium bank angles, the ailerons and rudder should be neutralized. Steep bank angles require opposite aileron and rudder to prevent the bank from steepening.

Back pressure on the elevator should not be relaxed as the vertical component of lift should be maintained if altitude is to be maintained. Throughout the turn, the pilot should reference the natural horizon, scan for aircraft traffic, and occasionally crosscheck the flight instruments to verify performance. A reduction in airspeed is the result of increased drag but is generally not significant for shallow bank angles. In steeper turns, additional power may be required to maintain airspeed. If altitude is not being maintained during the turn, the pitch attitude should be corrected in relation to the natural horizon and cross-checked with the flight instruments to verify performance.

Steep turns require accurate, smooth, and timely flight control inputs. Minor corrections for pitch attitude are accomplished with proportional elevator back pressure while the bank angle is held constant with the ailerons. However, during steep turns, it is not uncommon for a pilot to allow the nose to get excessively low resulting in a significant loss in altitude in a very short period of time. The recovery sequence requires that the pilot first reduce the angle of bank with coordinated use of opposite aileron and rudder and then increase the pitch attitude by increasing elevator back pressure. If recovery from an excessively nose-low, steep bank condition is attempted by use of the elevator only, it only causes a steepening of the bank and unnecessary stress on the airplane. Steep turn performance can be improved by an appropriate application of power to overcome the increase in drag. Depending on the purpose of a steep turn and the magnitude of control force needed, trimming additional elevator back pressure as the bank angle goes beyond 30° may assist the pilot during the turn.

Since the airplane continues turning as long as there is any bank, the rollout from the turn should be started before reaching the desired heading. The amount of lead required to rollout on the desired heading depends on the degree of bank used in the turn. A rule of thumb is to lead by one-half the angle of bank. For example, if the bank is 30°, lead the rollout by 15°. The rollout from a turn is similar to the roll-in except the flight controls are applied in the opposite direction. Aileron and rudder are applied in the direction of the rollout or toward the high wing. As the angle of bank decreases, the elevator pressure should be relaxed as necessary to maintain altitude. As the wings become level, the flight control pressures should be smoothly relaxed so that the controls are neutralized as the airplane returns to straight-and-level flight. If trim was used, such as during a steep turn, forward elevator pressure may be required until the trim can be adjusted. As the rollout is being completed, attention should be given to outside visual references, as well as the flight instruments to determine that the wings are being leveled and the turn stopped.

Because the elevator and ailerons are on one control, practice is required to ensure that only the intended pressure is applied to the intended flight control. For example, a beginner pilot is likely to unintentionally add pressure to the pitch control when the only bank was intended. This cross-coupling may be diminished or enhanced by the design of the flight controls; however, practice is the appropriate measure for smooth, precise, and accurate flight control inputs. For example, diving when turning right and climbing when turning left in airplanes is common with stick controls, because the arm tends to rotate from the elbow joint, which induces a secondary arc control motion if the pilot is not extremely careful. Likewise, lowering the nose is likely to induce a right turn, and raising the nose to climb tends to induce a left turn. These actions would apply for a pilot using the right hand to move the stick. Airplanes with a control wheel may be less prone to these inadvertent actions, depending on control positions and pilot seating. In any case, the pilot should retain the proper sight picture of the nose following the horizon, whether up, down, left, or right and isolate undesired motion.

Common errors in level turns are:

1. Failure to adequately clear in the direction of turn for aircraft traffic.
2. Gaining or losing altitude during the turn.
3. Not holding the desired bank angle constant.
4. Attempting to execute the turn solely by instrument reference.
5. Leaning away from the direction of the turn while seated.
6. Insufficient feel for the airplane as evidenced by the inability to detect slips or skids without flight instruments.
7. Attempting to maintain a constant bank angle by referencing only the airplane's nose.
8. Making skidding flat turns to avoid banking the airplane.
9. Holding excessive rudder in the direction of turn.
10. Gaining proficiency in turns in only one direction.
11. Failure to coordinate the controls.

Climbs and Climbing Turns

When an airplane enters a climb, excess lift needs to be developed to overcome the weight or gravity. This requirement to develop more lift results in more induced drag, which either results in decreased airspeed or an increased power setting to maintain a minimum airspeed in the climb. An airplane can only sustain a climb when there is sufficient thrust to offset increased drag; therefore, climb rate is limited by the excess thrust available.

The pilot should know the engine power settings, natural horizon pitch attitudes, and flight instrument indications that produce the following types of climb:

- Normal climb—performed at an airspeed recommended by the airplane manufacturer. Normal climb speed is generally higher than the airplane's best rate of climb. The additional airspeed provides for better engine cooling, greater control authority, and better visibility over the nose of the airplane. Normal climb is sometimes referred to as cruise climb.

- Best rate of climb (V_Y)—produces the most altitude gained over a given amount of time. This airspeed is typically used when initially departing a runway without obstructions until it is safe to transition to a normal or cruise climb configuration.

- Best angle of climb (V_X)—performed at an airspeed that produces the most altitude gain over a given horizontal distance. The best angle of climb results in a steeper climb, although the airplane takes more time to reach the same altitude than it would at best rate of climb airspeed. The best angle of climb is used to clear obstacles, such as a strand of trees, after takeoff. *[Figure 3-19]*

It should be noted that as altitude increases, the airspeed for best angle of climb increases and the airspeed for best rate of climb decreases. Performance charts contained in the Airplane Flight Manual or Pilot's Operating Handbook (AFM/POH) should be consulted to ensure that the correct airspeed is used for the desired climb profile at the given environmental conditions. There is a point at which the best angle of climb airspeed and the best rate of climb airspeed intersect. This occurs at the absolute ceiling at which the airplane is incapable of climbing any higher. *[Figure 3-20]*

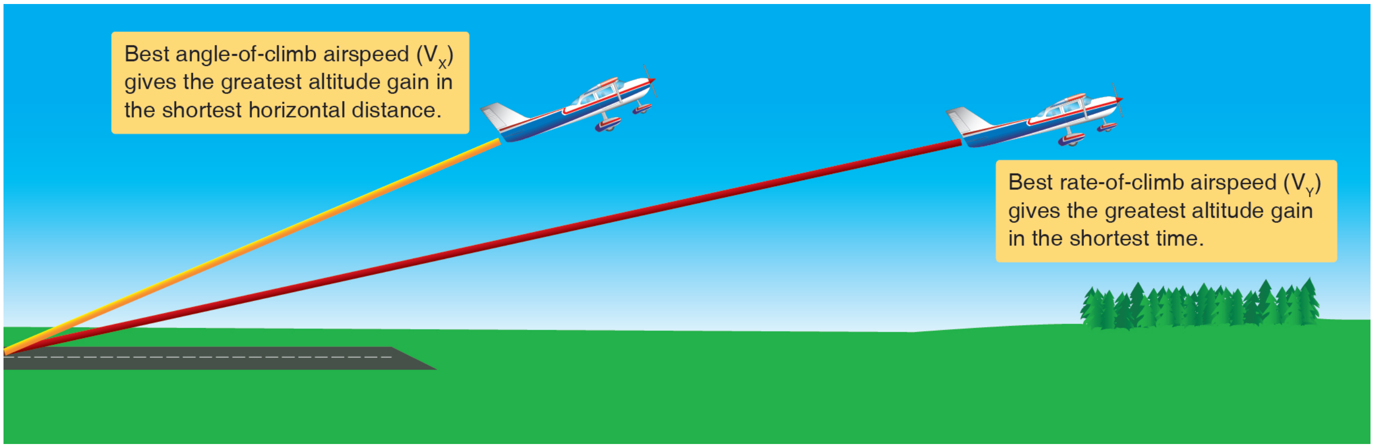

Figure 3-19. *Best angle of climb verses best rate of climb.*

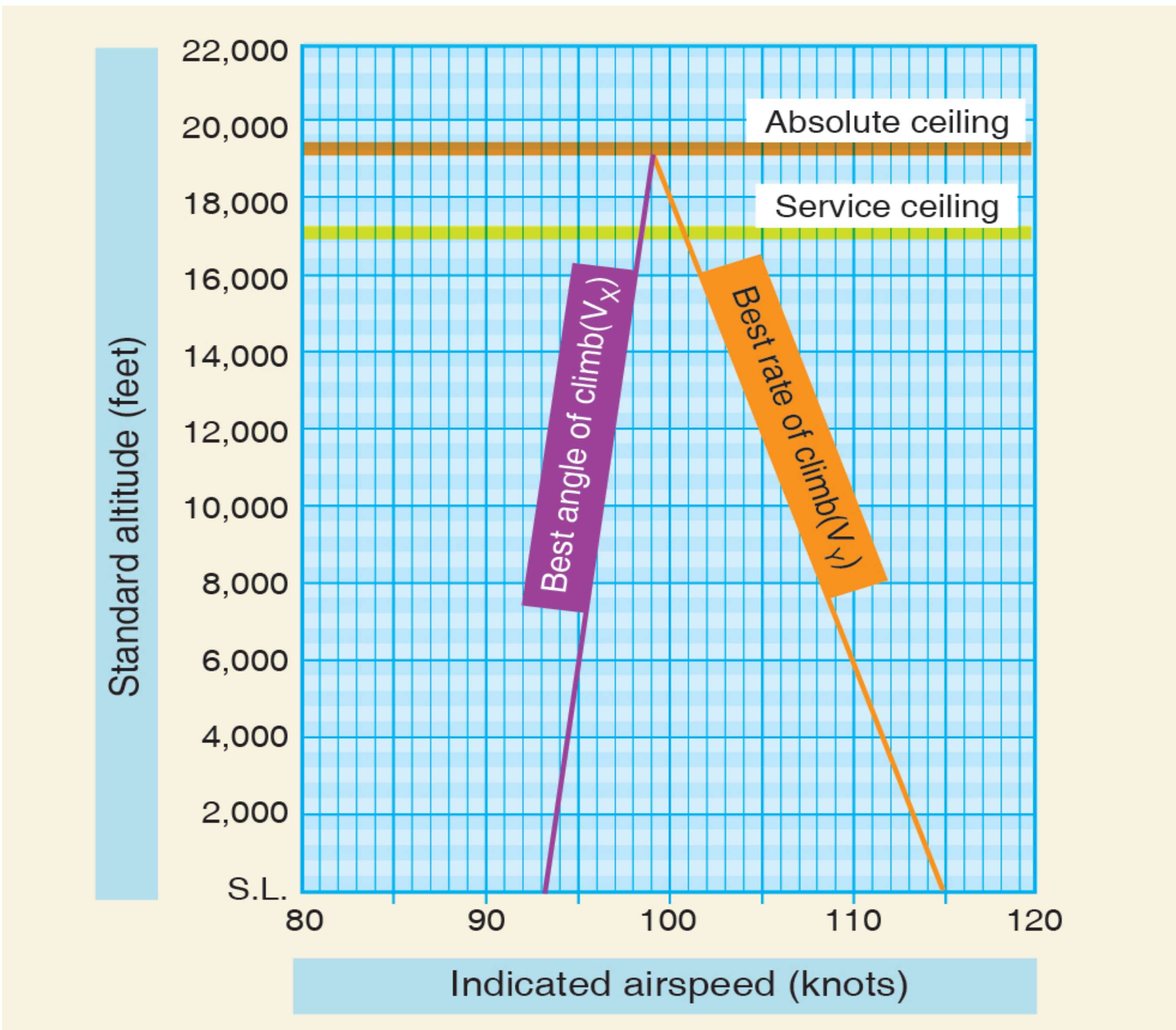

Figure 3-20. *Absolute ceiling.*

Establishing a Climb

A straight climb is entered by gently increasing back pressure on the elevator flight control to the pitch attitude referencing the airplane's nose to the natural horizon while simultaneously increasing engine power to the climb power setting. The wingtips should be referenced in maintaining the climb attitude while cross-checking the flight instruments to verify performance. In many airplanes, as power is increased, an increase in slipstream over the horizontal stabilizer causes the airplane's pitch attitude to increase more than desired. The pilot should be prepared for slipstream effects but also for the effect of changing airspeed and changes in lift. The pilot should be prepared to use the required flight control pressures to achieve the desired pitch attitude.

If a climb is started from cruise flight, the airspeed gradually decreases as the airplane enters a stabilized climb attitude. The thrust required to maintain straight-and-level flight at a given airspeed is not sufficient to maintain the same airspeed in a climb. Increase drag in a climb stems from increased lift demands made upon the wing to increase altitude. Climbing requires an excess of lift over that necessary to maintain level flight. Increased lift will generate more induced drag. That increase in induced drag is why more power is needed and why a sustained climb requires an excess of thrust.

For practical purposes gravity or weight is a constant. A vector diagram shows why more lift is necessary during a climb, as the vertical component of lift generated from the wings is no longer perpendicular to the wings and adds to drag. The total vertical force is increased by adding a vertical component of thrust from the powerplant, and the power should be advanced to the recommended climb power. On airplanes equipped with an independently controllable-pitch propeller, this requires advancing the propeller control prior to increasing engine power. Some airplanes may be equipped with cowl flaps to facilitate effective engine cooling. The position of the cowl flaps should be set to ensure cylinder head temperatures remain within the manufacturer's specifications.

Engines that are normally aspirated experience a reduction of power as altitude is gained. As altitude increases, air density decreases, which results in a reduction of power. The indications show a reduction in revolutions per minute (rpm) for airplanes with fixed pitch propellers; airplanes that are equipped with controllable propellers show a decrease in manifold pressure. The pilot should reference the engine instruments to ensure that climb power is being maintained and that pressures and temperatures are within the manufacturer's limits. As power decreases in the climb, the pilot continually advances the throttle or power lever to maintain specified climb settings.

The pilot should understand propeller effects during a climb and when using high power settings. The propeller in most airplanes rotates clockwise when seen from the pilot's position. As pitch attitude is increased, the center of thrust from the propeller moves to the right and becomes asymmetrical. This asymmetric condition is often called "P-factor." This is the result of the increased AOA of the descending propeller blade, which is the right side of the propeller disc when seen from the flight deck. As the center of propeller thrust moves to the right, a left turning yawing moment moves the nose of the airplane to the left. This is compensated by the pilot through right rudder pressure. In addition, torque that acts opposite to the direction of propeller rotation causes the airplane to roll to the left. Under these conditions, torque and P-factor cause the airplane to roll and yaw to the left. To counteract this, right rudder and aileron flight control pressures should be used. During the initial practice of climbs, this may initially seem awkward; however, after some experience the correction for propeller effects becomes instinctive.

As the airspeed decreases during the climb's establishment, the airplane's pitch attitude tends to lower unless the pilot increases the elevator flight control pressure. Nose-up elevator trim should be used so that the pitch attitude can be maintained without the pilot holding back elevator pressure. Throughout the climb, since the power should be fixed at the climb power setting, airspeed is controlled by the use of elevator pressure. The pitch attitude to the natural horizon determines if the pitch attitude is correct and should be cross-checked to the flight instruments to verify climb performance. *[Figure 3-21]*

Figure 3-21. *Climb indications.*

To return to straight-and-level flight from a climb, it is necessary to begin leveling-off prior to reaching the desired altitude. Level-off should begin at approximately 10 percent of the rate of climb. For example, if the airplane is climbing at 500 feet per minute (fpm), leveling off should begin 50 feet prior to reaching the desired altitude. The pitch attitude should be decreased smoothly and slowly to allow for the airspeed to increase. A loss of altitude may result if the pitch attitude is changed too rapidly without allowing the airspeed to increase proportionately.

After the airplane is established in level flight at a constant altitude, climb power should be retained temporarily so that the airplane accelerates to the cruise airspeed. When the airspeed reaches the desired cruise airspeed, the throttle setting and the propeller control, if equipped, should be set to the cruise power setting and the airplane re-trimmed.

Climbing Turns

In the performance of climbing turns, the following factors should be considered:

- With a constant power setting, the same pitch attitude and airspeed cannot be maintained in a bank as in a straight climb due to the increase in the total lift required. The airplane climbs at a slightly shallower climb angle because some of the lift is being used to turn the airplane.

- Steep bank angles significantly decreases the rate of climb. The pilot should establish and maintain an appropriate constant bank during the turn.

- The pilot should maintain a constant airspeed and constant rate of turn in both right and left turns. The coordination of all flight controls is a primary factor.

All the factors that affect the airplane during level constant-altitude turns affect the airplane during climbing turns. Compensation for the inherent stability of the airplane, overbanking tendencies, adverse yaw, propeller effects, reduction of the vertical component of lift, and increased drag needs to be managed by the pilot through the manipulation of the flight controls.

Climbing turns may be established by entering the climb first and then banking into the turn or climbing and turning simultaneously. During climbing turns, as in any turn, the loss of vertical lift should be compensated by an increase in pitch attitude. When a turn is coupled with a climb, the additional drag and reduction in the vertical component of lift need to be further compensated for by an additional increase in elevator back pressure. When turns are simultaneous with a climb, it is most effective to limit the turns to shallow bank angles. This provides for an efficient rate of climb. If a medium or steep banked turn is used, climb performance is degraded or possibly non-existent.

Common errors in the performance of climbs and climbing turns are:

1. Attempting to establish climb pitch attitude by primarily referencing the airspeed indicator and chasing the airspeed.
2. Applying elevator pressure too aggressively resulting in an excessive climb angle.
3. Inadequate or inappropriate rudder pressure during climbing turns.
4. Allowing the airplane to yaw during climbs usually due to inadequate right rudder pressure.
5. Fixation on the airplane's nose during straight climbs, resulting in climbing with one wing low.
6. Initiating a climbing turn without coordinated use of flight controls, resulting in no turn and a climb with one wing low.
7. Improper coordination resulting in a slip that counteracts the rate of climb, resulting in little or no altitude gain.
8. Inability to keep pitch and bank attitude constant during climbing turns.
9. Attempting to exceed the airplane's climb capability.
10. Using excessive forward elevator pressure during level-off resulting in a loss of altitude or excessive low G-force.

Descents and Descending Turns

When an airplane enters a descent, its attitude changes from level flight to flight with a descent profile. *[Figure 3-22]* In a descent, weight no longer acts solely perpendicular to the flightpath. Since induced drag is decreased as lift is reduced in order to descend, excess thrust will provide higher airspeeds. The weight/gravity force is about the same. This causes an increase in total thrust and a power reduction is required to balance the forces if airspeed is to be maintained.

Figure 3-22. *Descent indications.*

The pilot should know the engine power settings, natural horizon pitch attitudes, and flight instrument indications that produce the following types of descents:

- Partial power descent—the normal method of losing altitude is to descend with partial power. This is often termed cruise or en route descent. The airspeed and power setting recommended by the AFM/POH for prolonged descent should be used. The target descent rate should be 500 fpm. The desired airspeed, pitch attitude, and power combination should be preselected and kept constant.

- Descent at minimum safe airspeed—a nose-high, power-assisted descent condition principally used for clearing obstacles during a landing approach to a short runway. The airspeed used for this descent condition is recommended by the AFM/POH and is normally no greater than 1.3 VSO. Some characteristics of the minimum safe airspeed descent are a steeper-than-normal descent angle, and the excessive power that may be required to produce acceleration at low airspeed should "mushing" and/or an excessive rate of descent be allowed to develop.

- Emergency descent—some airplanes have a specific procedure for rapidly losing altitude. The AFM/POH specifies the procedure. In general, emergency descent procedures are high drag, high airspeed procedures requiring a specific airplane configuration (such as power to idle, propellers forward, landing gear extended, and flaps retracted), and a specific emergency descent airspeed. Emergency descent maneuvers often include turns.

Glides

A glide is a basic maneuver in which the airplane loses altitude in a controlled descent with little or no engine power. Forward motion is maintained by gravity pulling the airplane along an inclined path, and the descent rate is controlled by the pilot balancing the forces of gravity and lift. To level off from a partial power descent using a 1,000 feet per minute descent rate, the pilot should use 10 percent (100 feet in this example) as the distance above the desired level-off altitude to begin raising the nose and adding power to stop the descent and maintain airspeed.

Although glides are directly related to the practice of power-off accuracy landings, they have a specific operational purpose in normal landing approaches, and forced landings after engine failure. Therefore, it is necessary that they be performed more subconsciously than other maneuvers because most of the time during their execution, the pilot will be giving full attention to details other than the mechanics of performing the maneuver. Since glides are usually performed relatively close to the ground, accuracy of their execution and the formation of proper technique and habits are of special importance.

The glide ratio of an airplane is the distance the airplane travels in relation to the altitude it loses. For example, if an airplane travels 10,000 feet forward while descending 1,000 feet, its glide ratio is 10 to 1.

The best glide airspeed is used to maximize the distance flown. This airspeed is important when a pilot is attempting to fly during an engine failure. The best airspeed for gliding is one at which the airplane travels the greatest forward distance for a given loss of altitude in still air. This best glide airspeed occurs at the highest lift-to-drag ratio (L/D). *[Figure 3-23]* When gliding at airspeed above or below the best glide airspeed, drag increases. Any change in the gliding airspeed results in a proportional change in the distance flown. *[Figure 3-24]* As the glide airspeed is increased or decreased from the best glide airspeed, the glide ratio is lessened.

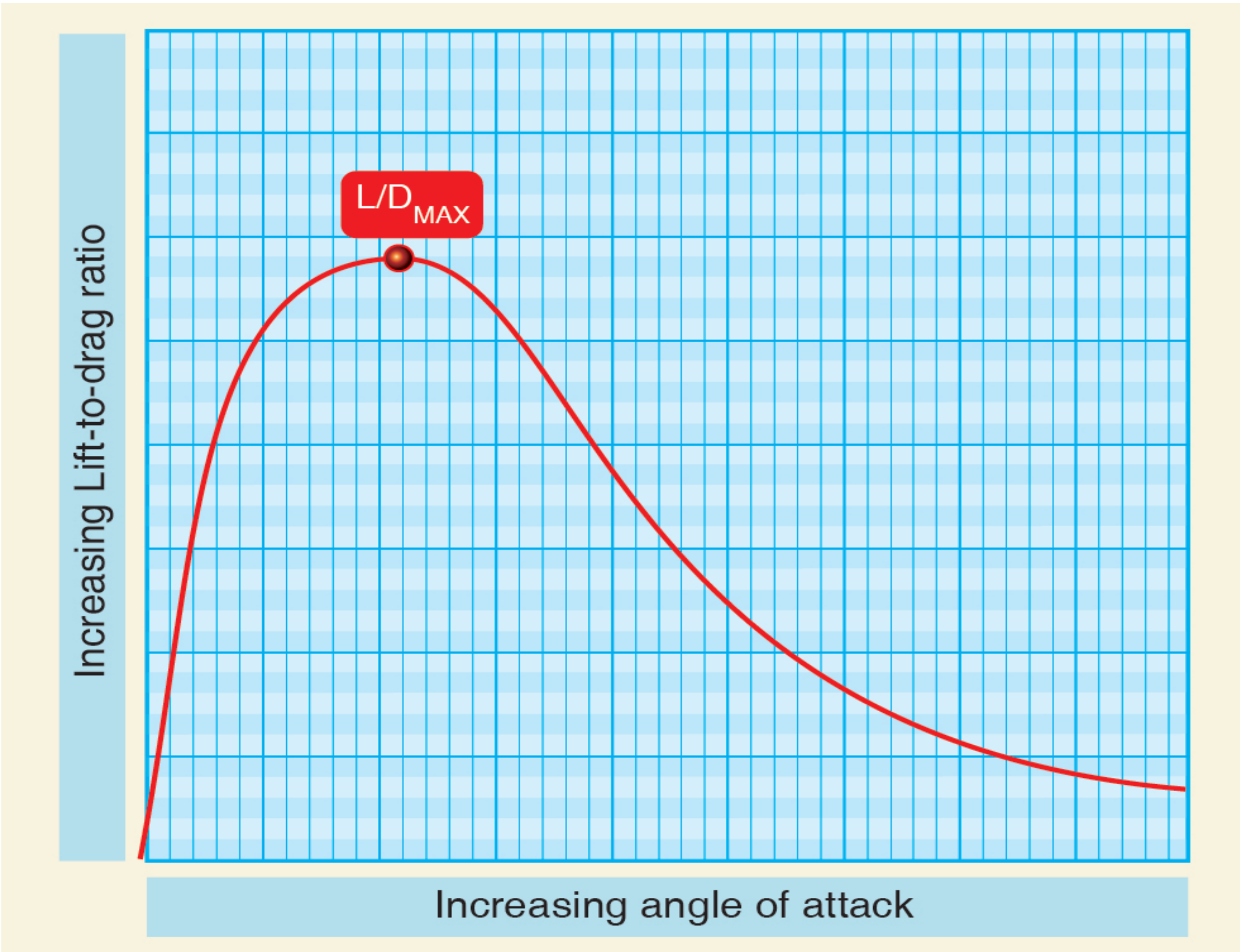

Figure 3-23. *L/D_{MAX}.*

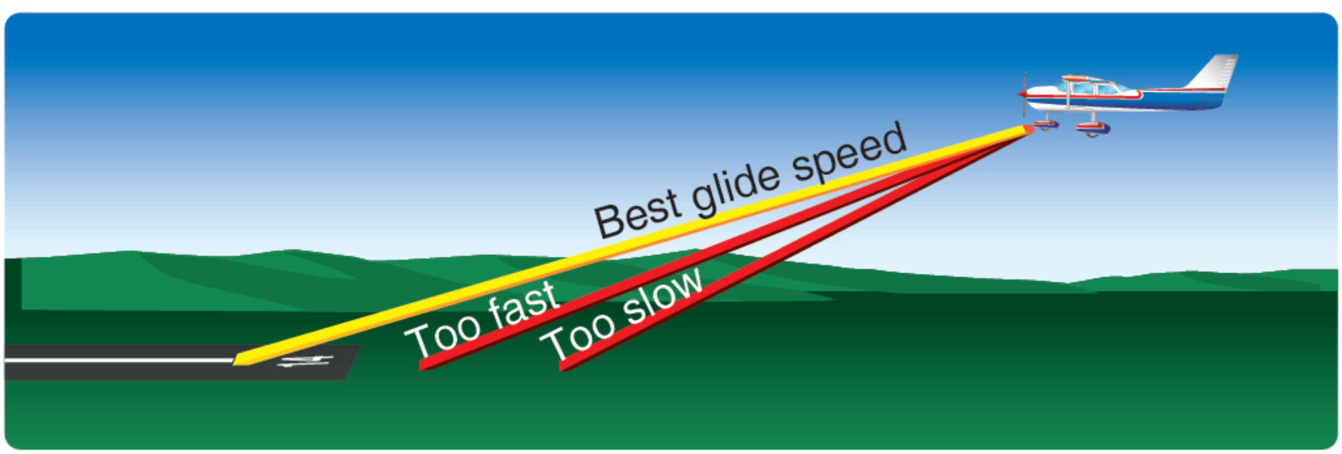

Figure 3-24. *Best glide speed provides the greatest forward distance*

Variations in weight do not affect the glide angle provided the pilot uses the proper airspeed. Since it is the L/D ratio that determines the distance the airplane can glide, weight does not affect the distance flown; however, a heavier airplane needs to fly at a higher airspeed to obtain the same glide ratio. For example, if two airplanes having the same L/D ratio but different weights start a glide from the same altitude, the heavier airplane gliding at a higher airspeed arrives at the same touchdown point in a shorter time. Both airplanes cover the same distance, only the lighter airplane takes a longer time.

Since the highest glide ratio occurs at maximum L/D, certain considerations should be given for drag-producing components of the airplane, such as flaps, landing gear, and cowl flaps. When drag increases, a corresponding decrease in pitch attitude is required to maintain airspeed. As the pitch is lowered, the glide path steepens and reduces the distance traveled. To maximize the distance traveled during a glide, all drag-producing components need to be eliminated if possible.

Wind affects the gliding distance. With a tailwind, the airplane glides farther because of the higher groundspeed. Conversely, with a headwind, the airplane does not glide as far because of the slower groundspeed. This is important for a pilot to understand and manage when dealing with engine-related emergencies and any subsequent forced landing.

During powered operations, the airplane design compensates for the effects of p-factor and propeller slipstream. While these effects disappear during a glide, the design compensation remains. During glides, it is likely that slight left rudder pressure will be required to maintain coordinated flight. In addition, the pilot needs to use greater deflection of the flight controls due to the relatively slow airflow over the control surfaces.

Minimum sink speed is used to maximize the time that the airplane remains in flight. It results in the airplane losing altitude at the lowest rate. Minimum sink speed occurs at a lower airspeed than the best glide speed. Flight at the minimum sink airspeed results in less distance traveled. Minimum sink speed is useful in flight situations where time in flight is more important than distance flown. An example is ditching an airplane at sea. Minimum sink speed is not an often published airspeed but generally is a few knots less than best glide speed.

In an emergency, such as an engine failure, attempting to apply elevator back pressure to stretch a glide back to the runway is likely to lead the airplane landing short and may even lead to loss of control if the airplane stalls. This leads to a cardinal rule of airplane flying: The pilot should not attempt to "stretch" a glide by applying back-elevator pressure and reducing the airspeed below the airplane's recommended best glide speed. The purpose of pitch control during the glide is to maintain the maximum L/D, which may require fore or aft flight control pressure to maintain best glide airspeed.

To enter a glide, the pilot should close the throttle and, if equipped, advance the propeller lever forward. With back pressure on the elevator flight control, the pilot should maintain altitude until the airspeed decreases to the recommended best glide speed. In most airplanes, as power is reduced, propeller slipstream decreases over the horizontal stabilizer, which decreases the tail-down force, and the airplane's nose tends to lower immediately. To keep pitch attitude constant after a power change, the pilot should counteract the pitch down with a simultaneous increase in elevator back pressure. This point is particularly important for fast airplanes as they do not readily lose their airspeed—any slight deviation of the airplane's nose downwards results in an immediate increase in airspeed. Once the airspeed has dissipated to best glide speed, the pitch attitude should be set to maintain that airspeed. This should be done with reference to the natural horizon and with a quick reference to the flight instruments. When the airspeed has stabilized, the airplane should be trimmed to eliminate any flight control pressures held by the pilot. Precision is required in maintaining the best glide airspeed if the benefits are to be realized.

A stabilized, power-off descent at the best glide speed is often referred to as normal glide. The beginning pilot should memorize the airplane's attitude and speed with reference to the natural horizon and note the sounds made by the air passing over the airplane's structure, forces on the flight controls, and the feel of the airplane. Initially, the learner may be unable to recognize slight variations in airspeed and angle of bank by vision or by the pressure required on the flight controls. The instructor should point out that an increase in sound levels denotes increasing speed, while a decrease in sound levels indicates decreasing speed. When a sound level change is perceived, the learner should cross-check the visual and pressure references. The learner should use all three airspeed references (sound, visual, and pressure) consciously until experience is gained, and then remain alert to any variation in attitude, feel, or sound.

After a solid comprehension of the normal glide is attained, the learner should be instructed in the differences between normal and abnormal glides. Abnormal glides are those glides conducted at speeds other than the best glide speed. Glide airspeeds that are too slow or too fast may result in the airplane not being able to make the intended landing spot, flat approaches, hard touchdowns, floating, overruns, and possibly stalls and an accident.

Gliding Turns

The absence of the propeller slipstream, , p-factor, loss of effectiveness of the various flight control surfaces at lower airspeeds, and designed-in aerodynamic corrections complicate the task of flight control coordination in comparison to powered flight for the learner. These principles should be thoroughly explained to the learner by the flight instructor.

Three elements in gliding turns that tend to force the nose down and increase glide speed are:

1. Decrease in lift due to the direction of the lifting force.
2. Excessive rudder inputs as a result of reduced flight control pressures.
3. The normal stability and inherent characteristics of the airplane to nose-down with the power off.

These three factors make it necessary to use more back pressure on the elevator than is required for a straight glide or a level turn, and they have an effect on control coordination. The rudder compensates for yawing tendencies when rolling in or out of a gliding turn; however, the required rudder pedal pressures are reduced as a result of the reduced forces acting on the control surfaces. A learner may apply excessive rudder pedal pressures based on experience with powered flight. This overcontrol of the aircraft may cause slips and skids and result in potentially hazardous flight control conditions.

Some examples of this hazard are:

- A low-level gliding steep turn during an engine failure emergency. If the rudder is excessively deflected in the direction of the bank while the pilot is increasing elevator back pressure in an attempt to retain altitude, the situation can rapidly turn into an unrecoverable spin.

- During a power-off landing approach. The pilot depresses the rudder pedal with excessive pressure that leads to increased lift on the outside wing, banking the airplane in the direction of the rudder deflection. The pilot may improperly apply the opposite aileron to prevent the bank from increasing while applying elevator back pressure. If allowed to progress, this situation may result in a fully developed cross-control condition. A stall in this situation almost certainly results in a rapid and unrecoverable spin.

Level-off from a glide is really two different maneuvers depending on the type of glide:

- First, in the event of a complete power failure, the best glide speed should be held until necessary to reconfigure for the landing. The pilot should plan for a steeper approach than usual. A 10 percent lead (100 feet if the descent rate is 1,000 feet per minute) factor should be sufficient to slow the descent before landing.

- Second, in the case of simulated power failure training, power should be applied as the 10 percent lead value appears on the altimeter. This allows a slow but positive power application to maintain or increase airspeed while the pilot raises the nose to stop the descent and re-trims the airplane as necessary.

The level-off from a practice glide should be started before reaching the desired altitude because of the airplane's downward inertia. The amount of lead depends on the rate of descent and the desired airspeed upon completion of the level off. For example, assume the aircraft is in a 500 fpm rate of descent, and the desired final airspeed is higher than the glide speed. The altitude lead should begin at approximately 100 feet above the target altitude. At the lead point, power should be increased to the appropriate level flight cruise power setting. The airplane's nose tends to rise as airspeed and power increase, and the pilot should smoothly control the pitch attitude such that the level-off is completed at the desired altitude and airspeed. When recovery is being made from a gliding turn to a normal glide, the back pressure on the elevator control, which was applied during the turn, needs to be decreased or the airplane may pitch up and experience a loss of airspeed. This error requires considerable attention and conscious control adjustment to re-establish a normal glide airspeed.

Common errors in the performance of descents and descending turns are:

1. Failure to adequately clear for aircraft traffic in the turn direction or descent.
2. Inadequate elevator back pressure during glide entry resulting in an overly steep glide.
3. Failure to slow the airplane to approximate glide speed prior to lowering pitch attitude.
4. Attempting to establish/maintain a normal glide solely by reference to flight instruments.
5. Inability to sense changes in airspeed through sound and feel.
6. Inability to stabilize the glide (chasing the airspeed indicator).
7. Attempting to "stretch" the glide by applying back-elevator pressure.
8. Skidding or slipping during gliding turns and not recognizing the difference in rudder forces with and without power.
9. Failure to lower pitch attitude during gliding turn entry resulting in a decrease in airspeed.
10. Excessive rudder pressure during recovery from gliding turns.
11. Inadequate pitch control during recovery from straight glide.
12. Cross-controlling during gliding turns near the ground.
13. Failure to maintain constant bank angle during gliding turns.

Chapter Summary

The four fundamental maneuvers of straight-and-level flight, turns, climbs, and descents are the foundation of basic airmanship. Effort and continued practice are required to master the fundamentals. It is important that a pilot consider the six motions of flight: bank, pitch, yaw and horizontal, vertical, and lateral displacement. In order for an airplane to fly from one location to another, it pitches, banks, and yaws while it moves over and above, in relationship to the ground, to reach its destination. The airplane should be treated as an aerodynamic vehicle that is subject to rigid aerodynamic laws. A pilot needs to understand and apply the principles of flight in order to control an airplane with the greatest margin of mastery and safety.