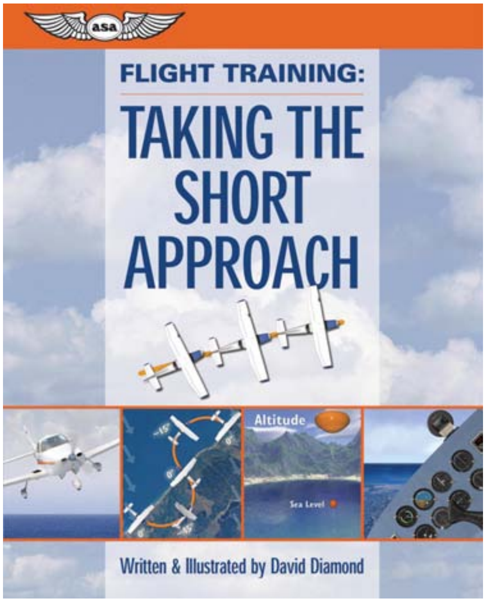
FLIGHT TRAINING: TAKING THE SHORT APPROACH (DAVID DIAMOND)


FLIGHT TRAINING:
TAKING THE SHORT APPROACH
Written & Illustrated by David Diamond


Flight Training: Taking the Short Approach by David Diamond provides all the information needed to make the decision to learn to fly and earn a pilot's license, streamlining the flight training process with a friendly, comprehensive orientation to aviation. With an easy conversational style and sense of humor that draws readers in, David Diamond speaks to you, student-pilot to student-pilot. This fresh approach is unique among aviation books and helps readers feel they are learning from a mentor/friend rather than an instructor. This book is your Flight Training 101 and you will find yourself turning time and time again to David Diamond's guidance and recommendations.

This ideal handbook for student pilots covers such topics as why people fly, the process of learning to fly—including money matters, time commitments, school and instructor options, and the tests involved. The author tackles and dispels common fears people have about learning to fly and takes you through an orientation of the airplane's controls and instrumentation, and the maneuvers you will be flying throughout training. The author is also the illustrator, providing some of the most engaging, descriptive, and exciting 3D illustrations found in any aviation book.

The result: you will enter your flight training program completely prepared, wasting no time or money at the airport or in the airplane. You will be "Taking the Short Approach" to flight training and you'll be glad you did.

David Diamond is a private pilot … not a flight instructor. He has no interest in flying for any reason besides the enjoyment of it. Diamond was also a founding member of the 80s rock group, Berlin, and it was during the band's first tour he experienced flight in a small airplane for the first time. Now a professional writer and 3D illustrator, Diamond wrote this book to fill a need he found during his own flight training: a book that spoke honestly about flying, the training required, and the human aspects that challenge the student pilot.

"I have read numerous books on the subject of flight instruction, and this is clearly the best that is on the market in every respect. This is the first publication to provide the prospective or current student pilot a true 'real world' perspective of what learning to fly is really all about.… The intuitive approach to the overall framework of the book…combined with the crystal clear explanations of at times difficult concepts, and literally the best illustrations and diagrams I have ever seen, serves to set this work apart from all others…this book will set a new standard in the field."
—Dr. Kenny Reed, Flight Instructor, L-39 type rating

"David Diamond has not just the Write stuff, but he's a foremost expert at 3D illustration—a powerful and rare combination when it comes to aviation instruction."
—Thomas Haines, Executive Editor, AOPA

"I'm a good pilot and I thought I had good instruction. But this book contains a lot of stuff I simply hadn't learned! This is the way it ought to have been taught all along. Makes me wish I didn't have this day job, so I could fly more often!"
—Roger O'Donnell, keyboardist for The Cure

"…Long on invaluable insight for the person seriously considering learning to fly…a fresh, thoughtful and complete view into the challenges and rewards on the path to becoming a pilot.…The value of The Short Approach will continue for the new pilot as a favorite reference and resource for years to come. I would loved to have had this book when I was deciding to become a pilot."
—Don Thompson, retired Delta Air Lines pilot

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The following pages contain the table of contents and an excerpt from "Flight Training: Taking the Short Approach," written and illustrated by David Diamond and published by respected aviation publisher ASA. (ISBN: 1-56027-556-1)

"Short Approach" offers an overview of the flight training process for those considering flight lessons and those already into their lessons. Unlike other aviation training books, "Short Approach" was not written by a professional flight instructor with thousands of hours of experience. Diamond is a private pilot who wanted to offer student pilots a different perspective on the process. He speaks to his readers as a mentor who well remembers that the rewards of earning a pilot certificate come only after many hours of confusion, frustration and self-doubt, which too many flight training experts simply dismiss as "flight training."

But even experts agree a book like this was a long time coming:

***Dr. Kenny Reed, CFI, Type Rating L-39** — "Like all pilots I know, I have read numerous books on the subject of flight instruction, and this is clearly the best that is on the market in every respect. This is the first publication to provide the prospective or current student pilot a true, 'real world' perspective of what learning to fly is really all about... Indeed, I think that history will confirm my belief that this book will set a new standard in the field."*

***Thomas Haines, Executive Editor, AOPA** — "David Diamond has not just the Write stuff, but he's a foremost expert at 3D illustration--a powerful and rare combination when it comes to aviation instruction."*

***Don Thompson, retired Delta Air Lines pilot with 36 years of flying experience** — "David Diamond's 'Short Approach' is long on invaluable insight for the person seriously considering learning to fly. This book gives a fresh, thoughtful and complete view into the challenges and rewards on the path to becoming a pilot. The reader will gain the knowledge needed to make the choice to fly. The value of 'Short Approach' will continue for the new pilot as a favorite reference and resource for years to come. I would loved to have had this book when I was deciding to become a pilot.*

***Barry Schiff, Aviation Author & Columnist** — "David Diamond has inspired me to write another book just so I can take advantage of his incredible illustrations."*

*To order the book, visit **http://amazon.com** or **http://www.asa2fly.com**. (Search terms: "Diamond Short Approach") Visit **http://AirDiamond.com** for information on Diamond's 3D graphics for aviation audiences. (Blue Internet links are active. Click one to open a web browser.)*

Figure 1: **THE REAL AIR TRAFFIC CONTROLLERS** Ailerons are controlled by turning the yoke left and right. They move opposite one another: as one goes up, the other goes down. Moving the yoke forward and back swings the elevator up and down. The rudder is controlled by the foot pedals and the flaps are either controlled by an electronic switch or a manual level, depending on the airplane model. The flaps, unlike the ailerons, move up and down in unison.

CONTROL ISSUES

Airplanes need to move in three dimensions. Conveniently, aircraft manufacturers equip airplanes with doohickeys called *control surfaces* that make this possible.

Control surfaces enable pilots to manipulate an airplane's *attitude*. When we say "attitude" in aviation we refer to the airplane's position in three dimensional space, not its cranky disposition. For example, is the airplane level? Pointed upward? Banked left? Upside down? Control surfaces make attitude adjustments possible by temporarily changing the shape of the airplane, thereby affecting the way the airplane interacts with the on-coming airflow, which we call the *relative wind*.

The control surfaces found on most trainers are illustrated in figure 1. They are:

- **Flaps** – Typically found inward on the airplane's wings, the flaps' primary purpose is to enable a steeper decent angle without an increase in airspeed. (You'll see how shortly.) Flaps are raised and lowered by an electronic motor or a manual hand lever, depending on the airplane model. Flaps always move in sync with one another. Technically, flaps are not considered a control surface because they do not change an airplane's attitude. But they fit nicely into this discussion.

Figure 2: **CONTROL SURFACE CONTROLLERS** An airplane's yoke(s) and foot pedals are used to control the ailerons, elevator and rudder. The yoke rotates left and right like a steering wheel to control the ailerons, and forward and backward to control the elevator.

- **Ailerons** – Working opposite one another (one flips up when the other flips down), ailerons (pronounced *ale'-eer-ons*) bank and turn the airplane. They're usually located alongside the flaps nearer the wing tips. Ailerons are controlled by turning the airplane's yoke (the airplane's "steering wheel") left and right. (Figure 2)

- **Rudder** – The rudder is attached to the airplane's vertical fin, which is called the *vertical stabilizer*. The rudder *does not* turn an airplane, but it does help an airplane turn properly. (Explained later.) The rudder is controlled using the airplane's foot pedals. The foot pedals are also used to steer the airplane when you're on the ground. (Figure 2)
- **Elevator** – The elevator is the flap-looking extension found on the rear of the airplane's horizontal stabilizer (the little wing at the back). Elevators force an airplane's rear either up or down, oppositely forcing the airplane's nose up or down for climbs and descents. The elevator is controlled by pushing the yoke forward (elevator down) and backward (elevator up).

A control surface is usually connected to the device that determines its position (yoke or foot pedals) by either a wire cable, metal rod, or both. No fancy connections are used here for good reason.

Using the most basic means of connecting flight controls to control surfaces, manufacturers reduce the likelihood that a control surface will become inoperable in flight. If your engine fails, your control surfaces continue to work. If your electrical system dies, your control surfaces continue to work. (Your flaps might be driven by an electric motor, but remember they are not actually control surfaces.)

Of all the airplane system failures that are possible, the loss of a control surface in flight can be the hardest to successfully overcome. This is not to say it's impossible to land an airplane with a control surface failure, but I'd personally rather land with a dead engine or electrical system. If a pilot safely lands an airplane after an engine failure, other pilots congratulate her on a job well done. If a pilot safely lands an airplane without the use of ailerons, that's one damn good (and lucky) pilot!

Figure 3: ***STRAIGHT AND LEVEL*** With no control surfaces deflected, this airplane flies straight and level. This configuration is also referred to as 'clean' because there is minimal interference with the relative wind.

Recall the U.S. military spy plane that was forced to land in China in March of 2001. While the rest of the world was debating who was to blame for the accident, the aviation community was simply in awe of the pilot's ability to land the plane with so much structural damage.

THE CONTROL SURFACE PURPOSE

The forward profile of an airplane is designed to minimize the surface area of the airplane that hits the on-coming airflow. This is a basic aerodynamic principle: the less surface area to interfere with the on-coming airflow, the more efficient the design. Car manufacturers employ similar design concepts in the interest of fuel efficiency and performance.

When an airplane is flying straight and level (not turning and not climbing or descending), control surfaces are *almost* in their neutral positions. I say almost because center-of-gravity factors and various turning tendencies that affect trainer airplanes force the pilot to usually deflect one or more control surfaces slightly just to remain straight and level. But for the purpose of this discussion, let's assume that in straight and level flight, the control surfaces are in their neutral positions. (Figure 3)

Figure 4: **CONTROL SURFACE DEFLECTION** The downward deflected right aileron (left) pushes the right wing up. The opposite happens on the other wing. Later we'll discuss how this turns the airplane.

When a control surface is moved, it temporarily changes the forward profile of the airplane. The oncoming airflow (relative wind) collides with the extended control surface and the control surface (with the airplane attached) and the relative wind each deflect to a certain degree. (Figure 4)

Airplane control surfaces work very much the same way a boat rudder works. When a boat rudder turns one way, the collision of the oncoming water with the rudder surface deflects each in opposite directions. The water is deflected one way and the boat's rear section is deflected in the opposite direction.

THE SURFACE VS. THE WIND

The balance of power in the battle between the relative wind and an airplane's control surfaces shifts as the airflow increases and decreases. The word we use to refer to these airflow velocity changes is *airspeed*. As airflow velocity increases, so increases our airspeed indication, and vice versa.

Control surfaces on slow moving airplanes, like those on slow moving boats, are less effective than they are when the vehicle is traveling fast. This is why large ships require the assistance of tug boats when moving through harbors; the ship is traveling too slowly for the rudder to have any useful effect.

As a vehicle picks up speed, the control surfaces become more effective, requiring less deflection to do their jobs.

Let's look at this more closely.

At slow airspeeds, the weaker relative wind is easily deflected by the control surface, hardly affecting the airplane's flight path at all. (Recall the large ship in the harbor.) When flying slowly, pilots must use exaggerated control inputs to get the airplane to respond.

As airspeed increases, the increasingly powerful relative wind eventually overpowers the control surface and the control surface must either yield (move) or break under the pressure. This is what changes the airplane's attitude. This is also what can cause control surface failures at excessive airspeeds. More on that later.

When the airplane's airspeed decreases, thereby decreasing the strength of the relative wind, the balance of power shifts back again. The airplane's weight and moment, and gravity eventually overpower the relative wind, making the control surfaces less effective.

If your airspeed declines enough so that the control surfaces have no effect whatsoever, they are said be *stalled*. Don't confuse a stall of this type with an engine stall. We typically don't use the term "stall" in aviation to describe a failed engine.

During your training you will practice flying your airplane as slowly as possible during a flight maneuver that's (not surprisingly) called *slow flight*. The purpose of slow flight is to get you used to the way the airplane's control surfaces behave with minimal airflow. Airplanes are harder to control when they fly slow and they tend to fly slow nearest the ground, during take-off and landing, when mistakes are least forgiving. This is why slow flight training is so important.

FREEWAY HAND FLYING

When I was a kid, I used to put my arm outside the car window, hold my hand at about a 20-degree angle to the horizon, and pretend my hand was an airplane wing. (Okay, I admit I still do this sometimes.) When the car was moving slowly, my hand would lie "grounded" on the top of the car door because the combined weight of my hand and arm overpowered any lifting force that my inefficient "handfoil" could generate.

But on speedier highways, my hand could fly! This was enormously cool and could entertain me for hours. As the car accelerated, my hand could eventually generate enough downward airflow deflection (lift) to overcome gravity.

As the car slowed, the amount of lift my hand was generating was reduced to the point where gravity won out. My hand would fall back down on the car door. If the car continued to accelerate, I would eventually have to reduce the angle at which I held my hand so it wouldn't fly all the way up to the car roof. Given a constant car speed (think airspeed), I could adjust the angle of my hand to determine its "altitude."

For the record, this variance of angle is called *angle of attack*. You'll hear more about that in ground-school and we'll talk a bit more about it later.

At the start of the hand/airflow conflict, my hand was the victor, forcing the relative wind to yield. But as the relative wind picked up speed (strength), the downward-deflected air from the bottom of my hand (lift) became stronger than gravity and my hand flew.

Airplanes work the same way: as the speed (strength) of the relative wind increases, the air colliding with the control surface becomes stronger, eventually overpowering the control surface's tendency to resist, thereby forcing the airplane to turn, climb or descend.

SPEED HIGHS

So what happens to a control surface if the relative wind becomes *too* strong because the airplane is flying too fast? The technical term is *structural damage*. For every airplane model there is an airspeed that manufacturers warn against exceeding. This is known as the airplane's *never-exceed* speed.

Airplanes have a series of specific airspeeds that are relevant for one reason or another: The never-exceed speed is one. The maximum speed at which flaps can be extended is another. The slowest airspeed at which the airplane can fly is another.

Collectively these are called *v-speeds*. I'm guessing that "V" stands for velocity. They are notated by a large V in front of one or more smaller characters that define the v-speed's meaning. Never-exceed speed is notated as V_{NE}. You'll see other v-speeds throughout the rest of this book.

Typically you'll never reach V_{NE} unless you're in an over-enthusiastic descent. The engine in your trainer simply won't have the power to get you there on its own. But if you're flying at full throttle and you point your airplane's nose downward, you're adding gravity to your thrust arsenal, so V_{NE} becomes a concern.

If you exceed V_{NE}, you can break a control surface, or worse.

SPEED LOWS

At the opposite end of the dangerous-speed index are what we call the *stall speeds*. Just like an individual control surface can stall, so too can an entire wing. When you hear someone say that an airplane stalled, they are usually referring to a wing stall.

There is a minimum amount of airflow that must pass over the wings to keep an airplane airborne. If during a flight, the airplane slows to the point

Figure 5: **SPIN** When one wing stalls before the other, it drops and the airplane might enter a spin. In this image the airplane's left wing stalled and dropped and the airplane entered the spin. This is the most common type of spin. Discuss spins and spin recovery with your CFI.

where this minimum amount of airflow isn't possible, the wings *stall*. A stalled wing produces no lift.

The nice thing about training aircraft is that they are designed to automatically recover from wing stalls with almost no effort on the pilot's part. For example, if your airspeed gets too slow and your airplane stalls, the airplane's nose drops and the airplane starts a descent. Can you guess what happens next? The airspeed increases, which is exactly what you need. When the airspeed climbs above stall speed, the wings once again generate lift and the stall is broken. This typically takes only a few seconds.

It's possible to stall one wing before the other. This can be dangerous and can lead to what we call *spins*. An airplane in a spin can be hard or impossible to recover. You aren't required to practice spins during your training, but you are required to understand how they can happen and how (in theory) you are supposed to recover from them.

There are a few types of spins, but luckily the most common is also the easiest to recover from. (Figure 5) The basic theory behind spin recovery is to apply full *opposite* rudder to the direction of the spin, relax pressure on the yoke, and then, after the spin has stopped, gently pull back on the yoke to return to level flight.

Let's think about this for a moment. What good would opposite rudder do? Have a look at figure 5. That airplane is spinning to the left. If the pilot applied full right rudder, try to visualize what the airplane would do. It would "kick" itself out of the spiral pattern.

But why relax the yoke when we're already falling so fast? If an airplane is spinning, it is also stalled. (An airplane cannot spin unless it is stalled.) Pulling back on the yoke will do nothing but ensure that the airplane remains stalled. We want the airplane to take advantage of its native design to help break the stall. This happens only if we relax the yoke pressure and just let the airplane "be."

After the spinning stops, you'd *gently* pull back on the yoke to get the airplane back to level flight. If you pull back too quickly, you might enter another stall if your airspeed is too slow, or damage the elevator if your airspeed is too high.

The most important thing I can tell you about spins is that more student pilots were getting killed each year practicing them than there were pilots killing themselves by unintentionally entering them. This is why the FAA ceased requiring spin training for private pilots. If you want to experience a spin, have an aerobatic instructor take you up. Chances are a normal CFI hasn't had much experience with actual spins. Things can go wrong. You might as well have someone in the cockpit that will consider any unforeseen circumstance as "fun."

As mentioned, an airplane cannot spin if it is not stalled. This is why it's important to always maintain an airspeed well above your stall speed, especially when flying within a few thousand feet of the ground, which is common when you're

Figure 6: **LONGITUDINAL AXIS** Extending from the airplane's nose backward, is the longitudinal axis. The ailerons rotate the airplane around this imaginary line.

setting yourself up to land. Your CFI will (or should) drive this point down your throat so I'll spare you here.

You'll practice stalling your airplane throughout your training. The idea to stall practice, however, is not to teach you how to stall an airplane, but to teach you how to safely recover from a stall. I went through the first 20 or so hours of my training wondering why it was so important for me to learn how to stall an airplane. When would I ever want to stall an airplane? I suppose I should have asked sooner.

AILERONS

Ailerons lift one wing while lowering the other. In essence they "roll" the airplane around an imaginary line that extends from the tip of the airplane's nose backward. This line is called the airplane's *longitudinal axis*. (Figure 6)

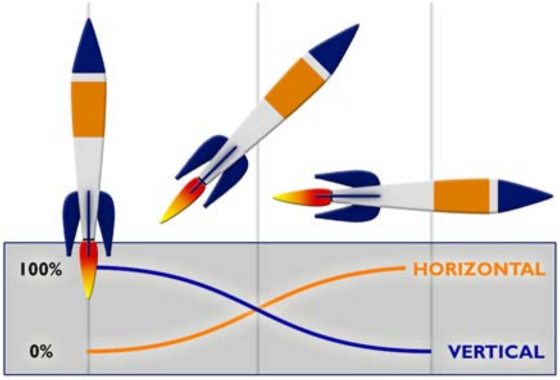

Figure 7: **LIFT SHIFT** A rocket's sole source of lift is the thrust generated by its engine. As the rocket tilts, part of that vertical lift is diverted sideways and pushes the rocket off in a new direction. The rocket starts to climb more slowly because of that loss of vertical lift. As the rocket continues to tilt, the remaining vertical lift is diverted sideways. The rocket is now traveling horizontally very fast, but will eventually tumble back to Earth because it has no more vertical lift to counter gravity.

Odd as it might seem, ailerons are what pilots use to turn airplanes. This concept confuses more than a few student pilots who assume that the rudder (described later) does all the turning. In fact, you don't need a rudder at all to turn an airplane.

So how does raising one wing higher than the other turn the airplane? The credit goes to lift. Only this time the lift isn't vertical, it's horizontal. Recall our discussion on how a wing's downwash helps propel the wing upward. So what happens to that downwash if the wing is tilted? Sidewash! This isn't an actual aviation term, but it helps illustrate what's going on when an aileron raises a wing.

Let's use a rocket as an example of how lift can shift from being vertical to being horizontal. A rocket uses the thrust of its engine as its only source of lift. But what happens if you turn a skyward-rocketing rocket slightly sideways? As you can guess, it starts to drift off to one side. This is because some of that vertical lift has been diverted to horizontal lift. (Figure 7)

The amount of lift the rocket engine generates is finite, so as some lift is diverted sideways, less is available to propel the rocket vertically. As the rocket starts to turn, it also starts to climb at a slower rate.

If you continued to tilt the rocket, it would continue on an increasingly horizontal path. Its vertical climb speed would also continue to slow as more and more lift was diverted horizontally.

Eventually the rocket would become horizontal. At this point there would be no vertical lift at all. The rocket would be traveling horizontally at maximum speed, but it would also start falling back to Earth because without any vertical lift, there is no force to overcome gravity.

Now let's relate this to an airplane. As the ailerons lower one wing and raise the other, the airplane, like our rocket above, tilts. What was once downwash lifting the wing has now become that "sidewash" we mentioned. The more the airplane tilts, the more downwash becomes sidewash.

Remember that "sidewash" is technically referred to as the *horizontal component of lift*. This horizontal lift "slides" the airplane one way or the other, depending on which wing is up. If the right wing is up, the airplane slides to the left. This continued process turns the airplane.

Okay, so now we have a sideways moving airplane. This still doesn't explain why it turns. But think about that big ol' tail sticking up at the back of the airplane we call the vertical stabilizer. What do you imagine happens when the airplane starts moving sideways? The oncoming airflow (relative wind) hits the tail, which creates some resistance and causes the back end of the airplane to slide sideways *less* than the front end. The net result is that the nose of the airplane is pointed in the direction of the turn and the airplane turns. (Figure 8)

Figure 8: ***TURNING TAILS*** As the horizontal component of lift shoots off to the left (large blue arrows), sliding this airplane toward the right, the vertical stabilizer (tail section) hits the oncoming sideways airflow (small blue arrow) and resists the slide. The result is that the nose slides more and the airplane turns.

The official answer to "What turns an airplane?" is *the horizontal component of lift*. The more complete answer is, "The horizontal component of lift shifts the airplane sideways. The vertical stabilizer resists the sideways movement and the nose of the airplane shifts faster. This turns the airplane."

Like a rocket's engine, the lift an airplane wing generates is finite. As we divert some of it sideways to turn, we lose some that we depended on to keep us aloft. The steeper the bank, the more of an issue this becomes. In order to maintain our altitude, we need to pull back on the yoke.

If we don't manipulate the yoke to compensate for the loss of vertical lift in a turn, we'll lose some altitude. We won't come crashing down to the ground, but we might fail our checkride. You are expected to maintain altitude within certain tolerances during all flight maneuvers to demonstrate that you understand the connection between horizontal and vertical lift.

A 45-degree turn yields a much tighter turning radius than does a 20-degree turn, but it also requires more back-pressure (pulling back) on the yoke to maintain the same altitude. (Figure 9)

Figure 9: *HORIZONTAL COMPONENT OF TIGHTER CIRCLES* As ailerons are deflected, part of the vertical lift is diverted horizontally, thereby requiring additional power to maintain airspeed and altitude. The more the ailerons are deflected, the more lift is diverted and the tighter the airplane's turning radius becomes. The large arrows in this image show the balance of lift shifting from vertical (right) to horizontal (left). If the airplane were turned completely sideways (90° bank), there would be no vertical lift left at all.

Adding back-pressure increases lift, but anytime you increase lift, you also increase drag. Knowing that thrust overcomes drag, you'll need to add some power when you turn if you want to maintain altitude and airspeed. If you don't add power you'll start to lose airspeed. When you start to lose airspeed, you'll start to lose lift. When you start to lose lift, you'll start losing altitude. To maintain altitude you'll need to pull back on the yoke, which increases drag. To compensate for the added drag, you'll need to add power.

So no matter which way you look at it, you need to do what you need to do. If you know what to do ahead of time, you'll be able to maintain your altitude and airspeed gracefully. Otherwise you'll be playing catch-up.

During your training you'll practice a maneuver called *steep turns* that demonstrates these concepts.

Summarizing ailerons:

- Ailerons work opposite one another: one goes up as the other goes down.
- Airplanes turn because of the horizontal component of lift, which is created when the ailerons bank the airplane.
- As horizontal lift increases, vertical lift decreases.

Ailerons are a great example of a control surface that you wouldn't want to lose. Can you turn an airplane without using the ailerons? Yes, using the rudder, but it's not an efficient thing to do. It's kind of like walking your dog by pushing on his tail.

But didn't I just say a page or so back that the rudder *doesn't* turn the airplane? I was actually telling you the truth. Only the horizontal component of lift can turn an airplane. The trick lies in generating horizontal lift by using only your rudder. After you read the next section you'll know how.

RUDDER

Let me be the first to say to you, "More right rudder!" You'll hear this phrase from your CFI more times than you can imagine. You'll hear it in your sleep.

The rudder rotates the airplane around another imaginary line called the *vertical axis*. (Figure 10)

If the wings generate the lift that moves an airplane up and down, and the ailerons are used to turn the airplane left and right, what's left to do? Who needs a friggin' rudder?

While it's true that you could fly much farther ignoring your rudder than you could ignoring some other control surface, your flight wouldn't be

Figure 10: *VERTICAL AXIS* The rudder rotates the airplane around its vertical axis. This affects the airplane's attitude, but it does not, in and of itself, turn the airplane.

very efficient with regard to aerodynamic sleekness. This is because single-engine prop airplanes have mysterious left-turning tendencies, which I'll let your groundschool instructor explain. (Okay, they're not really mysterious.)

So you have an airplane that's trying to turn slightly left and a rudder-fearing pilot whose compensating by using slight right aileron. The net result is increased drag. Use of the rudder enables pilots to offset the airplane's natural left-turn tendencies.

Let me clarify something. When I say "left-turning tendencies," I really mean "left-yawing tendencies." Yaw describes the alignment of the airplane's longitudinal axis to the airplane's flight path. Refer back to figure 6 to imagine the airplane's flight path in relation to its longitudinal axis.

For example, let's say that the airplane is flying straight ahead, but it's cocked to the left. Here we'd say it is yawed to the left. The application of right-rudder would fix this. By applying the rudder we rotate the airplane around its vertical axis, thereby realigning its longitudinal axis. (Figure 11)

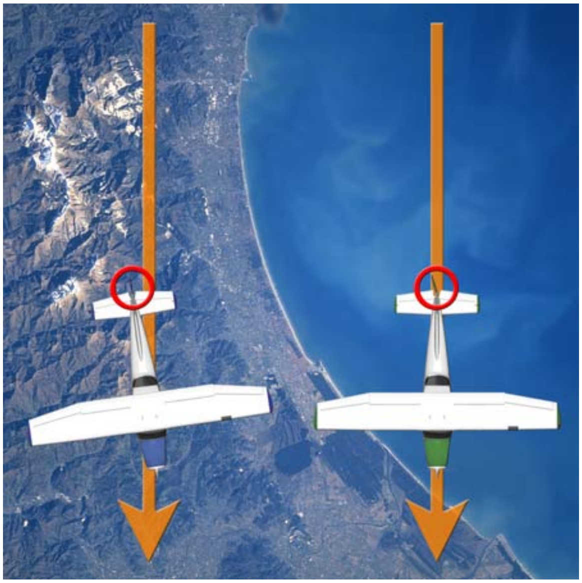

Figure 11: *RIGHT RUDDER!* The airplane on the left is yawed and no rudder correction has been applied. On the right, the pilot has applied proper rudder correction to (rudder circled) realign the airplane's longitudinal axis. A yawed airplane flies less efficiently because the relative wind hits the side of the fuselage, increasing drag.

It's a bit confusing to grasp at first, but keep in mind that anytime you manipulate an individual control surface, you are rotating the airplane around one axis to realign another axis. For example, let's say you deflect the ailerons to turn to the left. You are rotating the airplane around its longitudinal axis to realign its vertical axis. When you apply right-rudder to compensate for left-yawing tendencies, you are rotating the airplane around its vertical axis to realign its longitudinal axis.

I've heard commercial airliner pilots joke that they haven't used the rudder in years. This isn't actually truthful, but rather a joke underscoring the reduced need for constant rudder control in multi-engine airplanes, which lack the left-turning tendencies suffered by single-engine prop planes.

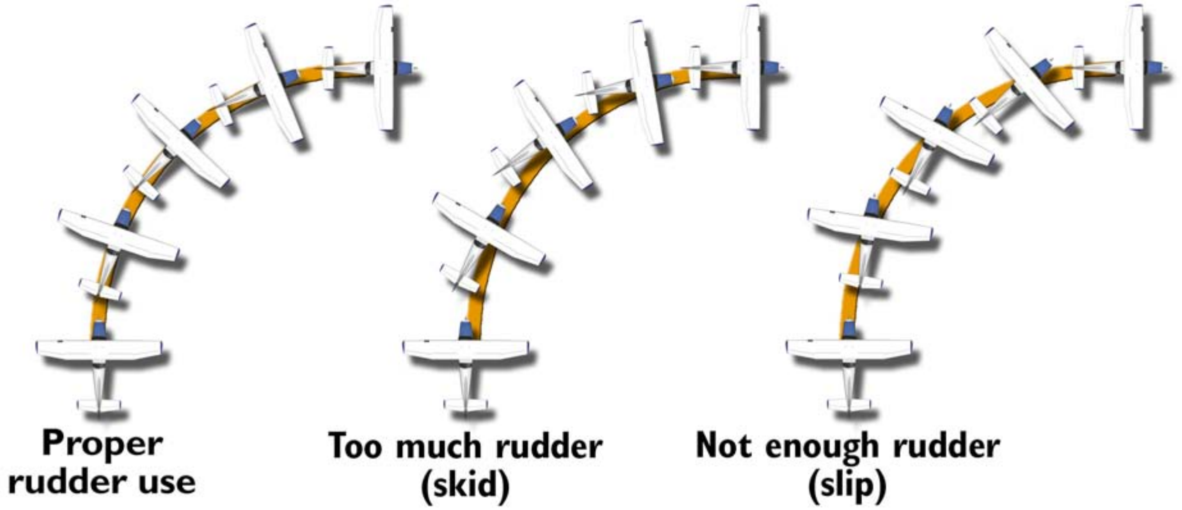

Figure 13: ***CLEAN TURNS*** When proper rudder pressure is applied, the airplane's longitudinal axis is aligned with the flight path (left). If too much rudder is used, the airplane's tail "skids" out. This is called a skidding turn (center). When a pilot fails to apply enough rudder, the airplane's tail "slips" inside the flight path, putting the airplane into a slipping turn (right).

During a turn, the rudder helps you align the airplane with the arced flight path. Because of the airplane's natural tendency to yaw to the left, you'll find that you sometimes don't need any rudder deflection on shallower left turns. You just reduce the amount of right-rudder pressure you were using to keep the airplane flying straight. (Figure 12)

What's really odd to me is that sometimes I need right rudder even in a left turn! This happens when the left turn is shallow enough so the left-yawing tendencies of the airplane are still overbearing. This is most noticeable during a climbing left turn. (The airplane's left-turning tendencies are increased during climbs.) Conversely, when you turn right, you need even more right-rudder. (Figure 13)

Can the airplane fly without this yaw correction? Sure it can, but less efficiently because the relative wind is now not only hitting the front of the airplane, but the side too. A sideways-cocked airplane isn't very aerodynamic and can, in some cases, be unsafe. So when I say that you can get away without using the rudder, don't assume I'm saying you don't really need your rudder. You can also fly with your eyes closed, but I don't recommend that either.

JUDGING PROPER RUDDER USE

So how do you know when you're using the rudder properly? Old-timers will tell you that if you *fly by the seat of your pants*, you'll know all you need to know. This is because it's possible to "feel" when an airplane is out of proper yaw alignment, especially in a turn. During a turn, you and your passengers shouldn't feel any sense of sideways pressure at all.

If the rudder is used properly, you feel nothing more than an increase in downward pressure against your seat. This increased pressure is caused by yet another evil natural force:

Figure 12: **RIGHT RUDDER, MAYBE!** The airplane's left-turning tendencies make the application of right rudder for the top airplane's right turn absolutely necessary. The pilot of the bottom airplane has applied no rudder pressure at all. The airplane's natural left-turning tendencies have aligned the longitudinal axis with the turn arc.

centrifugal force. Centrifugal force wants the airplane to continue flying in the direction it was flying before the turn started.

As we've discussed, you need an opposing force to counter each of these evil forces of nature. As luck and physics would have it, we have an opponent to counter centrifugal force. The horizontal component of lift takes on centrifugal force while your remaining vertical component of lift handles the ever-evil gravity.

But only with proper rudder use can the horizontal component of lift hit centrifugal force squarely on the jaw, thereby negating its side-pulling effect.

If while turning you feel yourself forced sideways one way or the other, then centrifugal force and the horizontal component of lift are not in balance. When the two forces are in check, you and your passengers feel no sideways force at all and sarcastic comments from your CFI about rudder use are minimized for the duration of the turn.

Imagine driving at 50 mph and turning on a flat surface. You'd feel a strong pull toward the direction in which you were originally driving. Your car might even skid. But if the turn were to happen on a banked roadway, like a highway on-ramp that was designed for the posted speed limit, you wouldn't feel the sideways force at all (unless you were traveling faster than the posted speed limit). The forces would be in balance, which makes the turn possible and safe. By using your rudder to keep the airplane properly aligned with the turning flight path, you can keep the forces in balance aloft too.

For those of us less attuned to "feel" and more attuned to gauge readings, there are flight instruments that can help. One is called a *turn & slip indicator* and the other is simply called a *turn coordinator*. Your airplane will have one or the other. The premise of these instruments is simple: keep a ball that is floating in liquid centered. If the airplane is yawed, the ball will be displaced. (Figure 14)

For the purposes of this discussion we're going to focus on the turn coordinator. Use of the turn and slip indicator is similar, but that instrument lacks the cool little airplane.

When the wings of the little airplane are aligned with either of the two angled tick marks on the turn coordinator, as shown in figure 14, the airplane is said to be in a *standard rate turn*, which is an 18-20 degree turn in most training airplanes. The word "standard" here applies more to aircraft flying under IFR than it does to you and me. VFR pilots use bank angles steeper than standard all the time. A "normal" turn for us will be about 30 degrees and a "steep" turn will require a 45-degree bank.

Figure 14: **TURN COORDINATOR** A turn is said to be coordinated when the ball (circled) remains centered throughout. In this image, the pilot must "step on the ball" with the right rudder to coordinate her turn. The airplane object is actually an indicator that tilts left and right. When level, it indicates the airplane is flying straight ahead. When the airplane's wing tip aligns with the lower tick marks, the airplane is in a standard rate turn. The "2 MIN" indication on the dial tells us that a 360-degree turn at standard rate will take 2 minutes to complete, though the exact timing can vary somewhat for each airplane.

IFR pilots limit themselves to this somewhat shallow bank angle to keep the possibility of spatial disorientation to a minimum and so that turns can be timed accurately. The "Two Minutes" indication on the turn coordinator's dial means that a 360-degree turn at standard rate will take two minutes. So a 180-degree turn would only take one minute. A 90-degree turn would take 30 seconds and so on. There are legitimate reasons for an IFR pilot to know how long a turn will take, but you'll learn about that during your instrument training.

It's easy to know which rudder pedal to use by remembering the phrase "step on the ball." For example, if the ball is to the right, step on it with the right rudder pedal until the ball centers.

TURNING AN AIRPLANE USING ONLY THE RUDDER

Here's the section I teased you about earlier. You can use a rudder (only) to turn your airplane, but it requires some brain flexing to understand why it works.

Think back to our conversation on lift. We know that in order to generate lift, there must be a certain amount of air flowing over the airfoil generating the lift. As that airflow decreases, lift is reduced. As the airflow increases, lift increases.

Okay, here's where the minor nuances of airflow over control surfaces really hits the old noggin with some impact. When you deflect the rudder one way or the other, you rotate the airplane around its vertical axis. This pushes one wing forward and pulls one wing backward. Airflow increases over the "forward" wing, which, in turn, increases the lift generated by that wing and the wing goes up. Airflow and lift decrease for the "back" wing so that wing drops.

And what happens when one wing is up and the other is down? We get that good ol' horizontal component of lift and the airplane turns. (Figure 15)

So, should pilots use the rudder turn the airplane? No, the rudder should be used only to adjust the airplane's yaw. Can a rudder be used to turn an airplane? Yes.

WHEN YOU SLIP YOU FALL

There are situations in which you'll purposefully want to displace an airplane's yaw to create additional drag. Our little airplanes don't have air brakes, so increasing drag is our only way of dropping airspeed and, optionally, altitude quickly.

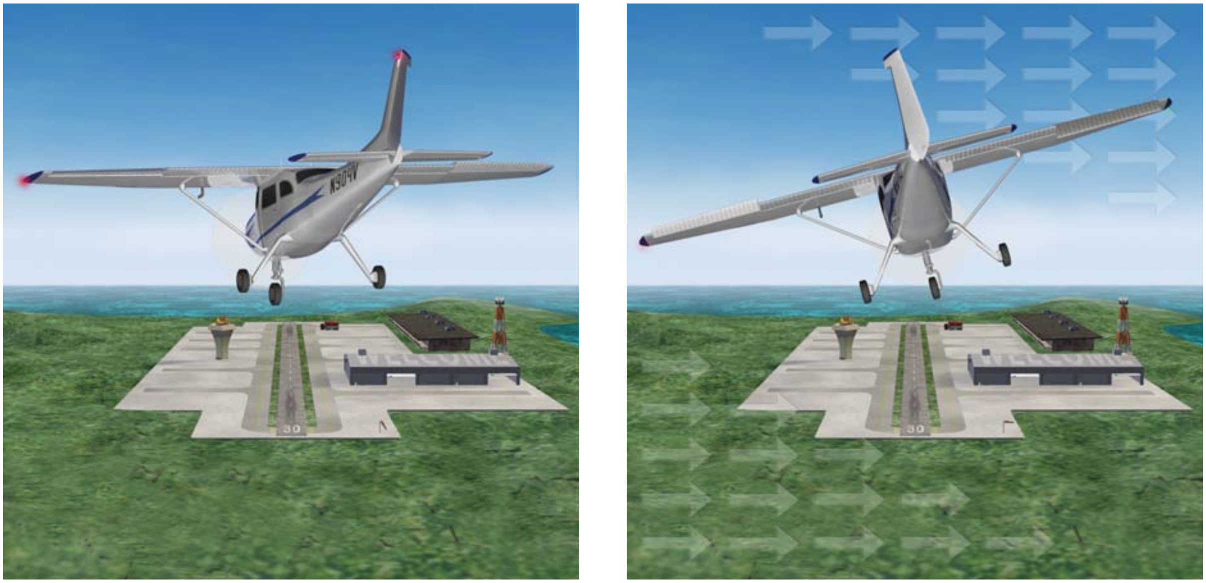

Figure 16: ***SLIP IT IN!*** The pilot on the left is using a side slip to drop airspeed and altitude on her final approach. (Winds are not an issue.) She has applied left rudder and just enough right aileron to cancel the effects of the left turn that would otherwise be caused by the "fast" right wing. There's a strong crosswind on the field in the right image, as indicated by the arrows and the very small windsock to the right of the 30 runway numbers. To compensate, this pilot is using a forward slip. Left ailerons are used to counter the force of the crosswind and opposite rudder is applied to straighten out the airplane's longitudinal axis. This slip can be maintained all the way through touchdown. The upwind wheel (left) will touchdown first.

Flap deployment increases drag, but flaps are not meant to be lowered and retracted quickly. What's more, lowering flaps at higher airspeeds can damage the flaps and the mechanism that controls them.

For a momentary "burst" of drag, pilots of small aircraft perform what we call *slips*.

There are two types of slips: *side slip* and *forward slip*. A side slip is usually used to quickly drop airspeed and, optionally, altitude. A forward slip is usually used to compensate for a crosswind during landing. Either can be used in just about any situation at the pilot's preference. (Figure 16)

Remember them like this: During a side slip, the airplane's longitudinal axis (nose to tail) is aligned sideways. During a forward slip, the airplane's longitudinal axis is aligned forward.

The idea behind a side slip is to rotate the airplane around its vertical axis in order to turn the airplane's fuselage into a giant air brake. Side slips are handy during an approach to landing when you can't use your flaps, or when you're above the speed at which it's safe to use your flaps, and you need to lose altitude and/or airspeed quickly.

To enter a side slip, you apply rudder in one direction while applying just enough aileron in the *opposite direction* to counter the turn tendency caused by the rudder. (Remember from figure 15 how the "fast" wing will raise and initiate a turn.)

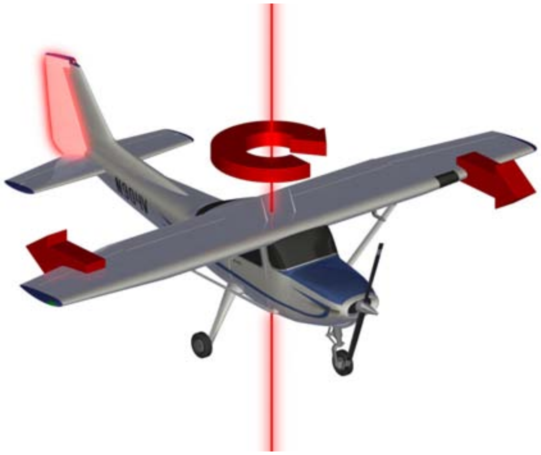

Figure 15: **RUDDER TAKING TURNS** A rudder can be used to turn an airplane without the use of ailerons. As the rudder rotates the airplane around its vertical axis, one wing is "pushed" forward while the other is "pushed" backward. The net effect is that the forward wing is "faster" and therefore generates more lift. Meanwhile, the opposite wing slows and generates less lift. The difference between the lift generated tilts the airplane on its longitudinal axis just like ailerons do. The horizontal component of lift takes it from there.

So if you use right-rudder, you'd turn the yoke to the left. This turns the airplane's fuselage somewhat sideways into the relative wind, thereby dramatically increasing drag.

You'll notice during slips that the ball of the turn coordinator is not centered. This is exactly what you want for a slip, and it helps illustrate how a non-centered ball during "normal" flight is less efficient. Whenever you see the turn coordinator's ball to one side or the other, you're in a slip or a skid, whether it's intentional or not.

So, when you're CFI is barking, "more right rudder!" it's because you're flying with the side of your airplane's fuselage facing into the relative wind.

Keep an eye on the airspeed indicator during side slips. You'll be amazed at how quickly it drops. You'll eventually need to reduce or remove the slip, or push the nose forward to maintain a safe airspeed.

You'll most likely use side slips intermittently, meaning that you'll enter one for 15 seconds or so and then release it. You won't enter a side slip and maintain it all the way to the ground. If you ever use a side slip near the end of an approach make sure you remove the slip before you touchdown on your main landing gear (the ones under the wings). The main landing gear is fixed in position, so if the airplane is in a side slip when you touchdown, the gear will hit the runway sideways. The gear could collapse if you hit hard enough.

Keep in mind that side slips are an option when you need them, but you might go many, many flights without ever using one. If you find that you frequently need them during approaches—the term used for the final phase of flight that precedes landing—you might want to reconsider how you set up your approaches. If you prepare for an approach properly, a side slip shouldn't be necessary.

Forward slips are used to counter crosswinds on landing. Crosswinds make it tough to keep the airplane properly aligned with the runway: you get yourself centered on final approach and then the wind blows you left or tight. The strength of the crosswind determines the amount of forward slip required.

To enter a forward slip, you'd apply as much aileron as necessary to counter the drift of the crosswind and keep the airplane centered on the runway. Effectively, you are turning into the wind to the same degree the crosswind is blowing the airplane sideways, thereby nullifying the drift influence of the wind. But since you are technically in a turn, however slight, one wing is high and the airplane's longitudinal axis is no longer aligned with the runway. This is where the rudder comes into play. Apply enough *opposite* rudder to straighten out the nose. So if you're turned to the right, use left rudder. Maintain this attitude right through touchdown.

During a forward slip the airplane flies straight ahead with one wing higher than the other. You'll touchdown on the low wheel first, which is the idea. This was very hard for me to grasp at first. My equilibrium just wanted that airplane to fly wings-level. It takes some getting used to, but it sure beats trying to find another runway that has no crosswind. (More on crosswind landings in "Crosswinds making you cross" on page 235.)

It's hard sometimes to keep the differences between the two types of slips straight. So let's summarize them for comparison:

- Side slips are primarily used to reduce airspeed and/or altitude at any stage of a flight.
- Forward slips are primarily used to counter crosswinds on landing.
- Side slips use the rudder as the primary control surface. Ailerons are used, as necessary, to keep the airplane flying straight ahead.
- Forward slips use the ailerons as the primary control surface. Rudder is used as necessary to keep the nose of the airplane aligned with the runway.
- Side slips turn the airplane's fuselage (longitudinal axis) sideways, thereby increasing drag and reducing airspeed. Wings remain level.
- Forward slips raise one wing, effectively turning the airplane into the crosswind. Rudder is used to align the fuselage (longitudinal axis) with the runway.
- Side slips must be removed prior to touchdown to avoid landing gear damage from the sideways impact.
- Forward slips are maintained throughout approach and touchdown to prevent the airplane from drifting off the runway.

Practice both types with your CFI. If your airport doesn't have significant crosswinds, find one that does and practice.

So you can see that the "useless" rudder actually has many uses. The coolest pilots avoid aviator sunglasses and use their rudders properly.

Summarizing the rudder:

- The rudder rotates the airplane around its vertical axis.
- The rudder helps coordinate turns by aligning the airplane's longitudinal axis with the turning flight path.
- The application of at least some right-rudder pressure is required most of the time in single-engine training airplanes because of their left-yawing tendencies.

If you lost your rudder during flight, you'd be in much better shape than if you'd lost your ailerons. And now, if you ever do lose your ailerons, you'll remember there's still a way to turn the airplane, albeit less efficiently.

Just be aware of the rudder's real purpose so if you ever do have to get along without it, you'll know what's been compromised. And keep an occasional eye on that ball in the turn coordinator. Keep it centered and your CFI will be so amazed that she'll not know what to do with herself.

ELEVATOR

The elevator is well named, doing exactly what you think it would do. It makes the airplane go up and down. Technically, we know that an increase

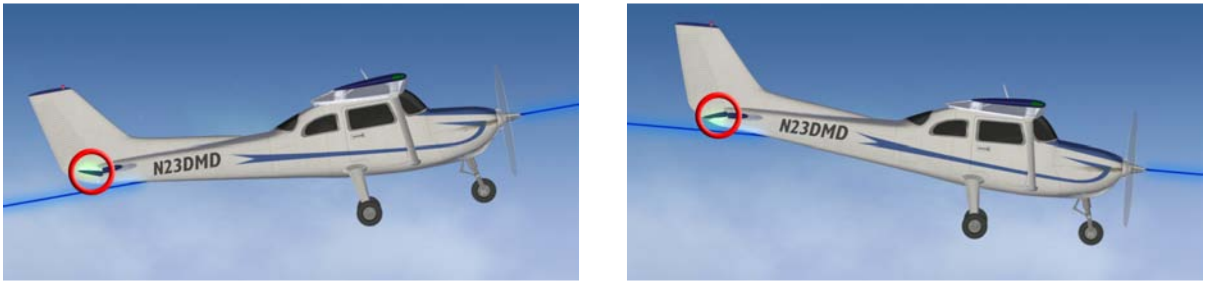

Figure 18: **GOING DOWN?** The elevator forces the tail section of the airplane up or down, which forces the nose oppositely. The rotation takes place around the airplane's lateral axis (the one that goes through the wings, not shown here), and realigns the airplane's longitudinal axis, shown here as a blue line.

Figure 17: **LATERAL AXIS** Extending from wing tip to wing tip is the airplane's lateral axis. The elevator rotates the airplane around this axis to climb and descend. The absolute position of the lateral axis depends on the airplane's center of gravity, which varies from flight to flight.

or decrease in lift is what makes an airplane go up and down, but the elevator helps us control the airplane's attitude so that we can, in turn, increase and decrease lift.

The elevator helps rotate the airplane around its *lateral axis*. (Figure 17) I say "help" because an increase or reduction in power will also rotate the airplane around the lateral axis to a degree. When you decrease power, the nose drops. This is also a rotation around the lateral axis.

The elevator is located on the rearward edge of the horizontal stabilizer, which is the smaller wing at the tail section of the airplane. Some airplanes, like the Piper Warrior, have what's called a *stabilator*, which is a horizontal stabilizer that rotates as a single unit. There is no separate elevator. Functionally, stabilators work the same as elevators. We'll use the term elevator to refer to both throughout this section.

Recalling our discussion on how an airplane's flight controls rotate the airplane on one axis in order to realign another axis, the elevator rotates the airplane on its lateral axis in order to realign its longitudinal axis up or down. (Figure 18)

When the elevator is raised, the rear of the airplane is forced downward, which raises the nose. This increases the amount of surface area on the underside of the wings that directly hits the relative wind. The degree at which a wing encounters the relative wind is called the airplane's *angle of attack*. (Figure 19)

The higher the nose, the higher the angle of attack. And the higher the angle of attack, the higher the *potential* for lift and the higher the drag. I say "potential" because without adequate power (thrust), higher angles of attack just produce additional drag.

Remember, drag is lift's evil nemesis. Where there is lift, there is drag. When lift increases, drag increases. If sufficient thrust is available to overcome the added drag brought on by the increased angle of attack, lift is increased and the airplane climbs. If there is not adequate thrust to overcome the added drag and enable the airplane to climb, the airplane simply loses airspeed.

This is a good time to think back to our discussion on stalls. You'll often hear about your airplane's *stall speed*, but then you'll also read that an airplane can stall at any speed. This baffled me to no end during my training. There are two *absolute* situations at which your airplane will stall. One is when your airspeed drops below a certain level (stall speed). No matter what your angle of attack the airplane will stall. The second situation is when your angle of attack has exceeded a certain degree, which is called the airplane's *critical angle of attack*. At that point, the airplane will stall no matter what your airspeed.

It's helpful to consider a wing's critical angle of attack like this: Do you expect a wing to generate lift when it's level with its flight path? Sure. Do you expect a wing to generate lift when it's at a 90 degree angle to its flight path? Of course not. It would be nothing more than a huge air brake at that point. So somewhere between "level" and 90 degrees must be the magical breaking point. That magic angle is the critical angle of attack.

Keep in mind an airplane's performance characteristics—including its critical angle of attack—take into consideration the airplane as a whole. So when Cessna says that a 172's critical angle of attack is *x* degrees, they say so assuming that the 172 will not be hot-rodded with the jet engine from an F-16. Considering the *available thrust*, the 172 has a given critical angle of attack. If the 172's engine was far more powerful, the airplane's critical angle of attack would be greater. Consider the many fighter jets that can climb vertically. They wouldn't be able to do so with the engine of a 172, regardless of wing design.

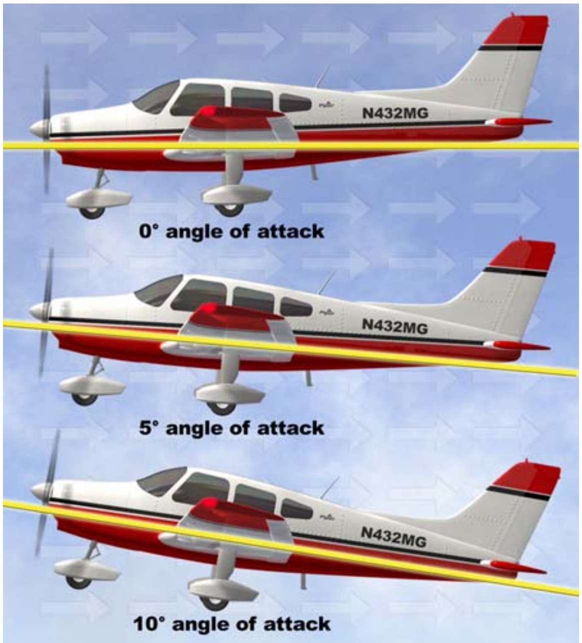

Figure 19: **ATTACK ANGLES** This airplane is shown at three different angles of attack, the angle of the bottom airplane being the greatest of the three. At greater angles of attack, the bottom of the wing encounters (and diverts down and back) more of the relative wind, thus increasing both lift and drag.

Think back to our freeway-hand-flying topic back on page 4. Given a constant airspeed (the speed of the car), we could generate more and less lift by gradually changing what we now know as the angle of attack of our hand. If we increase our angle of attack toward 90 degrees, our hand eventually "stalls" and drops because the drag caused by our hand's increasing vertical profile has overcome the lift produced. (I'm not sure what the actual critical angle of attack is for a hand!) Our lift-to-drag ratio has gone completely in favor of drag. We're generating no lift at all.

Get that car going 200 mph and your hand will "fly" at a much greater angle before stalling.

THE ELEVATOR'S PARTNER

Think of the elevator as a control surface with a full-time partner. This partner is the throttle control. Most of the time you make a significant change in the position of the elevator, you will also make a throttle adjustment.

For the purposes of this discussion, I want you to think of the throttle as the "thrust controller." Push it forward and it generates more thrust. Pull it back and it reduces thrust.

The partnership comes from the fact that changes in the elevator's position usually require either an increase or decrease in thrust.

When you push the yoke forward, thereby lowering the elevator, you force the airplane's nose downward. Gravity soon kicks in as a secondary source of thrust and the airplane's airpseed increases. To maintain your current airspeed, you reduce power (thrust) by pulling back on the throttle. If you don't reduce power, the two forces of thrust will cause your airplane to gain airspeed. If you ever look at the airspeed gauge on your airplane and wonder how the airplane could ever reach those higher numbers. Push the nose down without decreasing power and you'll find out.

The opposite happens when you pull back on the yoke. By raising the elevator, you increase lift and drag, which means your current power setting will probably be inadequate. The pee-shooter prop engines on most trainers are so meager that full-power settings are usually required for all climbs.

So, if a climbing airplane slows, does that mean we're somehow losing thrust? Technically no. We just "repurpose" thrust during climbs. Think back to what happens when an airplane turns. Part of the vertical component of lift generated by the wings becomes horizontal lift. It's still there, but it's now doing a different job. The same concept applies to thrust. When an airplane is flying straight and level, 100% of the engine's available thrust is being used to propel the aircraft horizontally. But when you point the airplane upward in a climb, a portion of the horizontal thrust becomes vertical thrust. With less available thrust to propel the airplane horizontally, it slows. Conversely, when the airplane's nose is pointing downward, the engine's vertical thrust is helping to drive the airplane down.

Summarizing the elevator:

- A downward-deflected elevator lowers the airplane's nose. A reduction in power is usually required to keep the airplane's airspeed from getting out of hand.
- An upward-deflected elevator raises the airplane's nose. An increase in power is usually required to keep the airplane's airspeed from falling too low.

Losing your elevator will make flight tough, but not necessarily impossible. As a substitute, you'd have to rely on power settings to climb and descend. You know that a faster airplane wants to climb and a slower one wants to fall. Use that knowledge to your advantage in case you ever have to fly without the use of your elevator. (Also ask your CFI to demonstrate how the elevator's trim tab can help too.)

A malfunctioning elevator stuck either up or down is very bad news. Most airplanes would not be able to overcome a mess like this. You might recall the Alaska Airlines jet that went down in the seas north of Los Angeles back in 2000. That crash was cause by an elevator that was stuck in a down position. The airplane entered a nose dive from which recovery just wasn't possible.

The elevator is a great control surface to check thoroughly during your preflight inspection.

FLAPS

Flaps are not considered control surfaces because they do not control an airplane's attitude, nor are they required for flight. But I figured this was a handy place to talk about them.

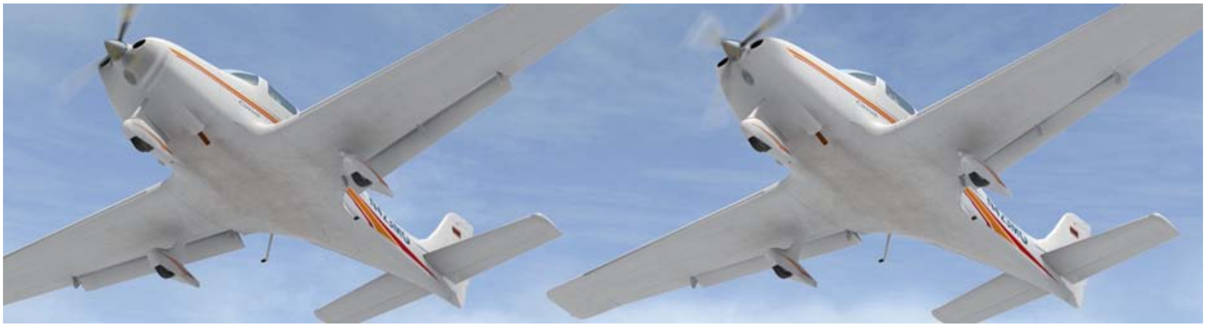

Figure 21: **FUN WITH FLAPS** Flaps increase lift and drag at the same time. The more the flaps are lowered, the more drag they introduce. Use of full flaps (left) enables an airplane to descend at a steeper angle without gaining airspeed. When flaps are lowered just a bit, say 10° (right), they increase the wing's ability to generate lift without introducing too much drag. This flap configuration might be used when the airplane is taking off from a grass or dirt runway (what we call a *soft field*) because the pilot wants to get the airplane out of the muck as soon as possible.

Figure 20: **TAKING OFF SOFTLY** This airplane has just departed from a grass airstrip (soft field) using partial flaps. The left (port) flap can be seen in this image just above the landing gear.

Flaps extend from the rear of the wing surface and remain flush with the wing when retracted, or flip downward when deployed. When deployed, flaps change the "shape" of the wing, from the perspective of the relative wind. (Figure 20)

There are many different types of wing flaps and I've yet to know why it's important for student pilots to understand the differences between them all. We'll leave that torture to your ground-school instructor.

Flaps can be lowered in varying degrees, which controls the effect they have. When deployed at lesser degrees, flaps increase lift and introduce only a small degree of additional drag. Some airplanes use small degrees of flaps for take-off. (Figure 21)

When deployed at higher degrees, the lift-to-drag ratio flips and the flaps introduce more drag than they do lift. This is the idea behind the use of full flaps when an airplane is inbound to land.

The FAA wants you to remember that flaps are used to *steepen descent angle without increasing airspeed*. This notion is right out of the FAA written test.

Technically the FAA's statement is true, but it's vague. Exactly *how* do the flaps steepen the descent angle without increasing airspeed? And why do I care? Further, the FAA explanation doesn't take into consideration the use of flaps on takeoff by some aircraft. But let's explore what they mean by steepening descent without increasing airspeed. (Get out your falsies, readers, it's time to get back to the drag bar.)

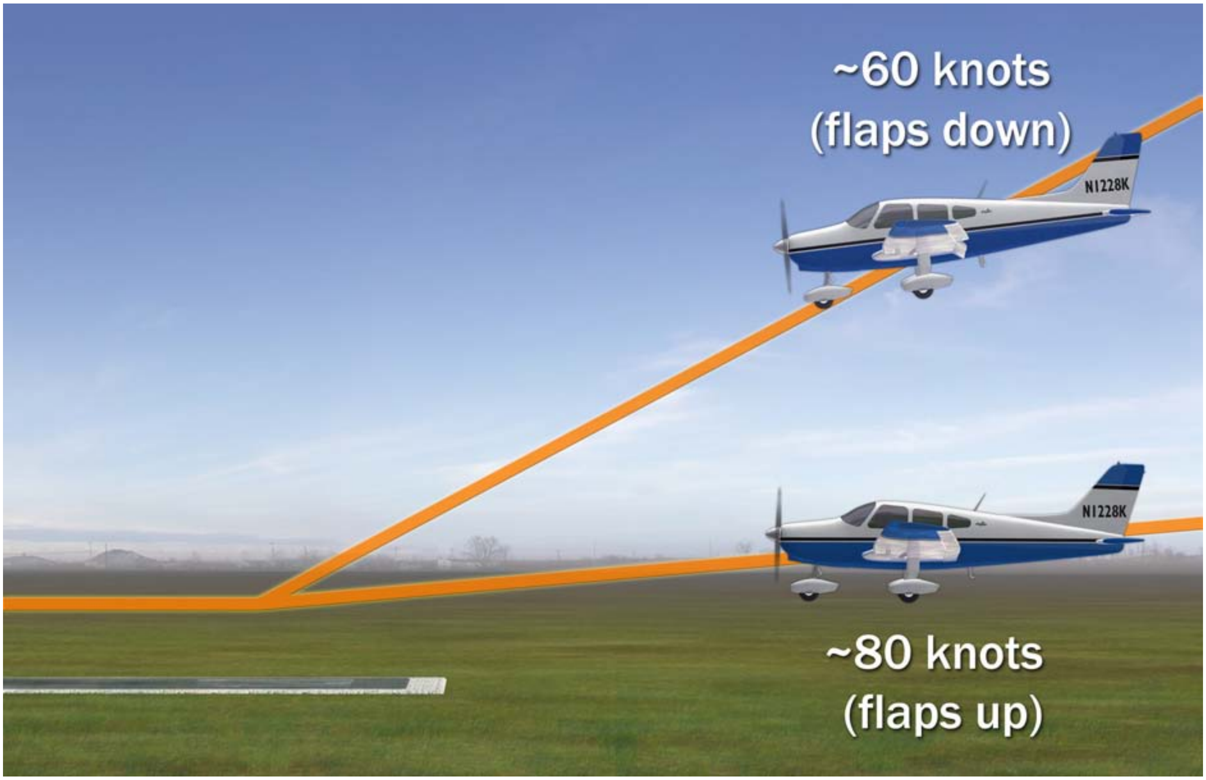

Figure 22: **HIGH OR LOW, FAST OR SLOW** Flaps increase drag and enable an airplane to descend at a steeper angle while still remaining relatively slow. Without flaps (and the increase in drag they provide) an airplane must come in at a shallower descent angle because a steeper angle would increase airspeed. Steep descent angles are preferable because they enable the airplane to maintain altitude for as long as possible and they help keep the airplane clear of ground obstacles that lie in the approach path. Slower airspeeds are preferable (unless there's a strong crosswind) because you want the airplane traveling as slow as safely possible when it touches down. Flaps also enable an airplane to fly at a slower airspeed before it stalls, so flap-less landings require some additional airspeed as a safety margin. You can land an airplane without flaps, and you should practice doing so. But under ordinary circumstances flaps can enhance safety, so use them.

Flaps deployed at higher angles increase drag considerably. Increased drag reduces the effect of the available thrust. Reduced thrust means reduced airspeed and less airspeed means less lift. When airplanes lose lift they descend. With absolutely no lift at all, an airplane would fall vertically like a rock. So by reducing lift with flaps, the airplane leaves level flight and descends at an angle somewhere between level flight and falling like a rock. (Figure 22)

But how do we steepen the descent angle without increasing the airspeed?

If while flying level you push the nose downward, you'll enter a descent. But you'll also pick up airspeed. It's like coasting down a hill without using brakes. The more you push forward, the steeper your angle of descent and the faster you'll go.

The important difference between a simple nose-down descent and a descent that uses flaps is that while you are in a nose-down, airspeed-increasing descent, you are *not reducing lift*. In fact, the increase in airspeed increases lift! You'll find yourself having to push down on the yoke harder and harder because the airplane will be fighting to stay airborne. And staying airborne is exactly *not* what you want to do when it's time to land.

So by forcing the nose down, you achieve only one of the functions of flaps: You increase your angle of descent. But the by-product is that you increase airspeed and, therefore, lift.

Don't get me wrong: if you force the nose down you *will* descend. It's not like the added lift will overpower you and force you to remain airborne forever. But you will also pick up airspeed, which you don't want when you're setting up to land. If you've got a lot of altitude to lose and want to pick up some time, go ahead and start a descent this way. But if you keep this angle all the way to the runway, you might find that you're trying to set the airplane down at 140 or so knots, when typically we touch down at 50 or 60 knots.

Common Speeds	Knots Per Hour (MPH / .8688)	Miles Per Hour (knots *1.151)
Lift off	55	63
Cruise Flight	110	127
In the Pattern	85	98
Final Approach	60	69

Fully deployed flaps *first* increase drag, which reduces airspeed. The airspeed reduction, in turn, reduces lift. This is why flaps, as the FAA says, can steepen your angle of descent without increasing airspeed. The airplane descends, but it doesn't gain unwanted airspeed. In fact, once those flaps are deployed, you'll need to force the nose down just to maintain airspeed.

Figure 23: ***FLAP FLIPPER*** Most Cessna trainers have flap-position switches located toward the bottom of the instrument panel on the passenger side. The "stair stepped" position settings enable the pilot to choose flap settings by "feel" without having to actually look at the switch. Cessna aircraft have electrical motors that actually move the flaps; these switches control those motors. Piper flap levers look (and work) like parking brake levers found in some cars. As you pull up on the lever, the flaps deploy. Piper flap levers are physically connected to the flaps by rods and cables.

There is a consistent relationship between lift, drag and the various flap positions. When flaps are retracted, they cause no additional lift and no additional drag. (Okay, the mere presence of their mechanical linkages probably adds a little drag, but forget that for now.) When flaps are lowered only slightly, say 10 degrees, they generate more lift than they do drag. Drop them down to 20 degrees and you're getting something near equal parts lift and drag. Extended to 30 or 40 degrees, flaps generate almost no lift at all, but add lots of drag. The ratio changes with each flap position. Cessna 172 flap positions are 10, 20, 30 and sometimes 40 degrees. If we had an enormously powerful engine that could generate enough thrust to overcome the massive drag imposed by flaps set to 40 degrees—and we had flaps that could withstand the force—then we could consider 40 degrees of flaps to generate lift too. (Figure 23)

Don't ever forget the role that thrust plays in relation to drag and lift. Given enough thrust, you can always overcome drag. (Remember that rocket whose engine generates 100% of its lift?) When an airplane manufacturer (or me) says that *x* degrees of flaps means a certain amount of lift or drag, we are considering the airplane as a whole, engine and all.

As mentioned, some airplanes use flaps for takeoff, usually extended to shallower positions, like 10 degrees. This helps increase lift and only slightly increases drag, which the engine is capable of overcoming. The Cessna 172 pilot's operating handbook (POH) recommends that flaps be extended to 10 degrees for soft-field take-offs. This added boost of lift enables the airplane to overcome gravity sooner and therefore less stress is endured by the landing gear as the wheels roll over the soft or rocky ground. There is added drag, but it's not too much for the engine to overcome. Extend a departing 172's flaps to 30 degrees or more, and you'd better have a very long runway with lots of wonderful scenery, because you won't be flying anywhere. The 172's engine is simply not powerful enough to overcome the drag imposed by 30 or more degrees of flaps on takeoff.

The only safe way of testing this theory is during flight. While flying with your CFI at a speed safe for flaps, lower your flaps to 30 degrees or more. Then pull back on the yoke and try to climb.You'll swear the yoke is directly attached to the airspeed indicator. As you pull back, you gain a slight amount of altitude, but you lose all of your airspeed.

This would be a different situation if you could press a magic button and double your engine's power. Then you could climb because the available thrust would more easily overcome the flap-added drag. (You might also find that your flaps rip right off of your wings because they are designed to withstand only a certain amount of relative wind resistance.)

You simply can't separate the relationship between thrust and drag.

Flaps are raised and lowered by an electrical motor on some training planes, such as the Cessna 172, while others, like the Piper Warrior, use a manual lever.

Can you land an airplane without the use of flaps? Certainly. And you should practice doing so with your instructor in case the day comes when you need to make a flapless landing.

One day I was flying a Cessna 172 and the airplane's alternator died. (That's the device that charges the airplane's battery.) My destination airport had no maintenance services, so I had to fly for a while until I could land somewhere else to have it fixed.

The first thing to consider after any airplane system failure is: *What did the system do and how do I compensate for its absence?*

The alternator charges the airplane's battery. Without it, I knew I was running my electrical system off of the airplane's battery and that meant I would lose electrical power within 30 or so minutes. (Your airplane's POH can help you determine how long you can expect your airplane's electrical system to remain on while running on battery power. Ask your CFI to help you determine this.)

I had been on Flight Following with ATC, so I wanted to let them know what was up. I radioed to them that I had lost my alternator and I was headed toward a certain airport for repairs. There was no reply. The radio display started flickering so I knew that power was fading fast.

I turned off all unnecessary electrical equipment, including my navigation equipment and radios. I left my transponder on so that I would continue to "blip" on ATC radar screens for as long as possible.

(Transponders use a lot of power, so if you ever find yourself in a serious electrical system emergency, consider that.)

I checked my charts and headed for the nearest airport that offered aircraft repair services.

Flying a partially disabled airplane, I wanted to maintain as many options as possible until I was absolutely certain that I could reach the airport. What caused the alternator to fail? I didn't know. Was my electrical system about to burst into flames? I didn't know that either. My intent was to get the airplane safely on the ground and let someone qualified sort it all out.

The best source of "options" for a pilot is altitude. Altitude gives you time and distance (in the case of an engine loss), and affords you a choice of directions to fly. If you're flying at 2,000 feet with 3,000 foot hills to the north, east and west, then your flight direction choice has been made for you. So I knew that I wanted to maintain my altitude for as long as possible until I knew with absolute certainty I could reach my airport.

By the time I reached the airport and tried to lower the flaps, I got about 5 degrees worth before the battery died completely.

No flaps for me.

Another failure and another decision to make: *What did the system do and how do I compensate for its absence?*

Flaps steepen the angle of descent without increasing airspeed, as we know very well by now. Could I emulate this?

Let's consider the effect of flaps step by step:

- Flaps increase drag, which slows the airplane.

Okay, how could I slow the airplane without flaps? I had the obvious choice of reducing power, which I did. But even with a power reduction I was flying too fast to lose the altitude that I needed to lose to get down to the airport in a reasonable amount of time. I needed to increase drag even more.

A side slip was the answer. Using a slip I was able to steepen my descent angle without increasing my airspeed. But there was one remaining very important thing that flaps do that I needed to consider:

- Flaps increase lift, which allows the airplane to fly slower without stalling.

So without the added lift generated by lowered flaps, I knew my airplane would stall at a higher airspeed. The answer was to come in for my landing faster than normal to ensure I had a speed buffer.

The landing went fine and the repairs were made. It's funny how a pilot's "urgent descent" could so quickly become a mechanic's routine alternator swap.

Later, in "The Electrical System" on page 138, I'll admit what I did wrong during this approach and landing.

Your CFI will go over stalls and stall speeds with you in detail. This is very important stuff. Make sure you understand it.

So in summary we know that:

- Flaps increase drag.
- Flaps increase lift. (Anything that increases lift also increases drag.)
- Flaps reduce the speed at which the airplane can fly before stalling.

Keeping these three things in mind will make it easier for you to fly and land without the use of flaps in case you ever need to. Remember, pilot training is all about what to do when something goes wrong.