You don’t need a weatherman, because you have ground reference maneuvers and from those you will learn to know which way the wind blows.

Who cares? You do, because you ultimately want to land the airplane and a landing is nothing more than the ultimate ground reference maneuver. It’s the primary reason we practice ground reference maneuvers in the first place. And once you get the hang of it, it’s a breeze, even with a brisk wind.

This chapter is second in importance only to Chapters Two and Three that cover the fundamentals of flight. Your ability to master the wind, or at least understand how it affects an airplane, is an essential element in being able to land anything that flies and can be piloted (hummingbirds and pterodactyls are excluded). That’s why we’re going to spend time talking about how the wind affects the airplane during flight.

Let’s begin with what happens to the airplane the moment it leaves the ground.

**Once Upon a Calm Day**

Let’s imagine that it’s a calm day—a no-wind, you-win situation (and you should run to Vegas and bet big on the wheel because it’s your lucky day). Now let’s imagine that you are accelerating along the runway and have just rotated to climb attitude. Immediately after liftoff,
the airplane points straight down the center of the runway, as long as you don’t let it get squirrely or hit a squirrel during the takeoff roll.

If you maintain the runway heading, the airplane will continue flying straight down the extended runway centerline. It does so because there is no wind (solar or otherwise) to blow it off that line. This is just another way of saying that the airplane tracks the runway centerline (Figure 1). For pilots, the motto is, “Keep on trackin’.”

Think of the term track as a reference to the steel rails of a railroad. One thing that’s certain about railroad tracks is that they don’t move once they’re spiked to the ground. They follow an established direction in much the same way an airplane follows a specific path over the ground in a no-wind situation, as long as the heading is constant. Another way of looking at this is that the airplane moves along the ground in the same direction the nose points.

Once there’s wind, however, this is no longer true. Game on.

**A Wind-Wind Situation**

You only have to spend a few hours aloft to begin wondering whether Mother Nature ever intended for an airplane to go where its nose points. She didn’t.

Perhaps this explains how pilots who are ignorant of the ways in which wind affects their airplane become lost. They don’t so much fly to a specific destination as they unexpectedly arrive at a random one. If it weren’t for the airport name on the gas receipt, they wouldn’t know what to put in the destination section of their logbook. After awhile, they run out of excuses for their behavior so when they land somewhere they pretend that it’s the place they intended to go.

If the wind only blew directly on the nose or tail of every airplane in flight, this chapter would be a lot shorter. In fact, we’d be done by now. Mother Nature, however, is not so accommodating. Most of the time the wind blows at some angle to your intended flight path. Left uncorrected, the effect is to blow the airplane off its intended course. Your job as a pilot is to compensate for this drifting tendency. And just to wind up the wind challenge, the direction from which the wind blows rarely remains constant for very long; it varies both horizontally and vertically as your position changes.

If the wind blows from the north at 20 knots, then the local atmosphere is literally moving across the ground a distance of 20 nautical miles for every hour that passes. If you were in a small hot air balloon and lifted off into this large moving block of wind, you would drift 20 nautical miles in one hour’s time, as shown in (Figure 2, position A). Toto, we’re not in Kansas any more.
While drifting, would you feel any wind blowing on you while moving? Not at all (unless it’s from localized gusts). That’s because you are a stationary object within this moving block of wind (yes, you’re an object in this example, deal with it). It’s the block of wind that’s moving. You, the balloon and the block of wind are all moving the same way, at the same speed. Their speed relative to one another is zero. Stick your arm out over the side of the balloon and you’ll find the air to be perfectly still (and other balloonists will think you’re signaling to make a turn). In fact, if you didn’t look at the ground it’s unlikely you’d even know you were moving.

Airplanes also drift with a moving block of wind. In addition to this drift, however, they have forward movement generated by the engine. This movement can be directly with, directly against, or at an angle to the way the block of wind is moving.

The airplane in (Figure 2, position B) has a true airspeed of 100 knots, meaning it is moving at 100 knots through the block of air. The block of air is moving at 20 knots, and as remarkable luck would have it, they are both moving in the identical direction. The airplane’s speed over the ground is a combination of the wind and airplane airspeeds. Adding the wind speed to our true airspeed gives us a speed over the ground (groundspeed) of 120 knots. Free speed. Take it while you can, because I’m about to take it back.

The airplane in Figure 2, position C also moves through the block of air at 100 knots. But now the block of air is moving at 20 knots in a direction opposite that of the airplane. That’s knot as good. We now have a net groundspeed of only 80 knots (100-20=80).

As an aside, it’s important to notice that making a 180 degree turn when flying into a 20 knot headwind changes your net groundspeed by 40 knots, not 20 knots (120-80=40). This is why airplanes can have radical changes in their ground tracks and groundspeeds when maneuvering in strong winds. This is one more mighty reason to understand how to maneuver with reference to the ground when wind exists.
Air Bullies

Winds are the bullies of aviation in that they typically push you where you don’t want to go. Bad bully! Take a look at what happens to an airplane attempting to follow a road with a wind from the left (Figure 3). While the airplane heads (points) directly down the road in Figure 3, position A, it drifts to the right in Figure 3, positions, B, C and D. Our airplane’s ground track is a combination of the motion of the airplane and the motion of the air. The angle between the desired course and the actual ground track is called the drift angle. It’s the amount of air drift by which you’re adrift. By determining the drift angle and correcting for it, you can fly a ground track exactly along the chosen course, as shown in Figure 4. This is the aviation equivalent of punching a bully in the nose (or getting one of your homies named Brick Armbar to do it for you).

Let’s be clear here. You cannot stop drift (air or continental). What you are going to do is compensate so that by flying slightly into the wind, drift acts to put you right where you want to be. You know intuitively how to do this. Think about swimming across a swiftly-moving stream. You know that if you swim straight, the sideways motion of the water will carry you downstream. You have to swim somewhat upstream in order to land directly across from where you started. As a pilot, you have a slipstream rather than a wet stream, but the principle remains the same. You need to swim up the River Air a bit.

How do you determine the drift angle from the cockpit? You might use the eyeball method. That’s right. Look out your windscreen at the ground reference you’re trying to track and determine the direction of drift. How do you correct for wind drift? Swim upstream. Head the airplane into the wind by making a coordinated turn and rolling out at an angle to the original course that stops the apparent drift and allows you to track the intended ground reference. Get my drift? The amount you turn into the wind to stop the drift is known as the wind correction angle or WCA.

Now you’re ready to get squared away—well, sort of—because it’s time to study your first ground reference maneuver, known as the rectangular course. I had a student once who thought I’d said “rectangular Coors” and he kept waiting for a beer can that doesn’t roll when you drop it.

But First. . .

There are a few things that apply to all the maneuvers we’ll discuss in this chapter. It’s important to take note of these things, because you will be working at relatively low altitudes and sometimes at
slow speeds and/or steep bank angles. I’ll say these things once, with the understanding that you will apply them to every maneuver we’re about to discuss.

**Mind your FARs.** If you can meet the requirements of FAR 91.119(c) for being over an uncongested area, then you will perform most of these maneuvers at anywhere from 600 to 1,000 feet AGL and not less than 500 feet above any person, vessel, vehicle or structure (Figures 5A and 5B). If you are over a congested area (Figure 5C and 5D) you must remain at least 1,000 feet above the highest obstacle within a radius of 2,000 feet, in accordance with FAR 91.119(b). A congested area, of course, makes it impossible to perform any maneuver at 1,000 feet AGL unless the houses and buildings are all flattened out to the thickness of a dime. If that’s the case, you’ve entered the alternate dimension of Flatland. So be sure to extend your airplane rental time.

In all the maneuvers that follow, when I propose an altitude of 1,000 feet or less, if you are over a congested area simply adjust that number upward as needed to make you legal. The FARs rule.

**Clear.** Be doubly certain to always clear the area before each maneuver. You’re at an altitude low enough that helicopters, traffic inbound to an airport, crop dusters, and even flying squirrels become traffic factors. You’re going to be busy dividing your attention between outside and inside. Make sure you’re in the clear before starting.

**Fly Coordinated.** Always make only a coordinated turn to change direction, even if the change is small. In these maneuvers you will frequently need to make small course changes. Do not—N-O-T—start nudging the nose around using just the rudder. This isn’t how you turn an airplane. I know it’s tempting to just give it a little nudge with the rudder. Don’t. Not even a little. In addition to being bad stick-and-rudder technique, this is an invitation to Spin City and you don’t want to go there, unexpectedly, at a low altitude.

**Limit Your Bank.** When performing the maneuvers in this chapter, try keeping bank angles at 45 degrees or less to reduce the risk of stalls. Stall speed does increase a little at 45 degrees of bank, but certainly not as much as it would in a 60 degree bank.

And now we’re ready. Even if you’re a square, you’re about to be rectangular.
The Rectangular Course

The first ground reference maneuver you’re likely to learn in flight training is also the one you’re most likely to use, and that’s the rectangular course, of course (Figure 6). The physical objective of this maneuver is to maintain a ground track that’s parallel and offset from a rectangular course while correcting for the effect of wind drift. The educational objective is to teach you how to anticipate the effect of wind on your airplane with respect to references on the ground as well as to help you learn to divide your attention between flying the airplane and tracking a ground reference.

The rectangular course uses geometry similar to that used in flying the traffic pattern when approaching to land at an airport. Just to get you in the landing mode and mood, we’ll refer to each side of the rectangular course using the same terms we use for the traffic pattern: the upwind leg, crosswind leg, downwind leg and base leg as shown in Figure 6 (more on traffic patterns in the next chapter). Master the rectangular course and you’re one step closer to being able to land an airplane.

Before you can learn how to track a rectangular course, you need to find one. It’s not as if your local flight school uses a bulldozer and an urban renewal permit to dig a rectangular trench through the “hood” that’s easily seen from the air and just happens to align most of the time with the wind.

You can usually use a traditional city block or a rectangular field (soccer, football), assuming they have city blocks or rectangular fields where you fly. The ideal is to have each side approximately one mile in length, but you may have to be creative and adaptable. Unless you’re a Jedi master with a “road and wind” endorsement on his light saber, it’s unlikely you can move roads and alter the wind in search of the perfect rectangle. Sometimes the best you can do is a sub-optimal rectangle where only one side lies at a 90 degree angle to the wind (see Sometimes You Just Can’t Get a Square Deal).

Let’s suppose you’ve found a rectangular course oriented perpendicular to the wind. Of course, if no wind exists, then tracking those sides is easy. You simply keep the nose pointed parallel with each side as you fly around the perimeter of the course (Figure 6). Easy, huh? Well, hang on a second before you injure yourself patting yourself on the back.

Flying a rectangular course is easy in a no-wind condition (Figure 6). You simply point the airplane’s nose parallel to any side of the course and your ground track will remain parallel to the course. Using the same strategy when wind is present (Figure 7), results in the airplane drifting downwind when flown at an angle to the wind’s direction.
Chapter 7 - Ground Reference Maneuvers

Sometimes You Just Can't Get a Square Deal

It’s unlikely that you know Stribog, the Slavic god of the winds, personally. So it’s unlikely that a personal call from you, me or anyone else will convince him to aim his galactic leaf blower in a way that directs the winds precisely perpendicular to the four intersecting roads you selected for your rectangular course. That's why it’s doubtful that you'll find a rectangular course having sides precisely aligned with and/or parallel to the prevailing wind.

So be practical. Choose a course with winds blowing as close as possible to 90 degrees (or parallel) to the relevant sides. If you live in a roadless area where it’s difficult to find a rectangular course to follow (Picture-1), then improvise. For instance, if you have no official roads because your county still favors the donkey as its primary means of travel and transport, then find rows of trees or other landmarks you can track from the air. We’ll settle for a close approximation of a rectangular course (Picture-2).

Sometimes you can find a rectangular course that lies within the Class D airspace of a tower-controlled airport (Picture-3). If so, and if this course isn’t directly in the common path of incoming or outgoing traffic, you’ve just scored big time. It’s like having a guardian angel with radar. How so? Tower power. The nice controllers in the tower are going to help look out for you. No extra charge. By asking the tower controller if you can practice your rectangular course maneuver within their airspace, you let them know you’re there. They in turn are likely to direct traffic away from you whenever possible. If that doesn’t happen, you at least have the controller advising other airplanes of your location, altitude and intentions and giving you a heads-up as well. Of course, you’ll have to remain in contact with the tower at all times, but that’s a small price to pay for the help offered.

With wind, you’ll need to apply a wind correction angle to track the course. What happens if you try flying a rectangular course without correcting for the wind? You can see the results in Figure 7. By flying a heading parallel to each side of the course without correcting for the wind, your ground track looks more like a wrecked angle than a rectangle. Only an amoeba has fewer parallel edges.

Your airplane will drift with the wind on the downwind and upwind sides of the course, which is something you wouldn’t want happening when you’re trying to fly a rectangular traffic pattern at an airport. After all, the traffic pattern helps pilots operate in an orderly sequence for landing. If you get blown away from or toward the runway, that makes it harder for other airplanes to see you, much less follow you (or for you to see and follow other airplanes).

So let’s see what it takes to fly this maneuver and make the ground track come out rectangular by applying a wind correction.

Begin by flying in the direction the wind is blowing, which I’ll refer to as flying downwind. The wind is at your back. You enter the maneuver this way because this is how you typically enter the traffic pattern—downwind.

This means you need to know the wind’s direction. How do you find that out? Sticking your hand out the window is not going to give you what you need, though it might give you some things you don’t need (think “missing watch”). If you are still relatively close to the departure airport, use the wind reported there at takeoff. You most likely departed an airport rather than launching off an aircraft carrier in your Cessna, right?
Various Ways to Identify Wind Direction

There are various methods of detecting wind direction from the air. The first is from steam or smoke stacks (position A). Windmills are another good indication since they point into the wind (position B). Cows (and other herbivores) are even known to stand with their tails the wind so as to see downwind and smell predators coming from upwind (position C).

Forgot the wind direction at takeoff? Clues are all around on the ground. Just pick one such as smoke from a smokestack (Figure 8, position A), the direction the local windmills or wind turbines are pointing (Figure 8, position B), the way flags are flying on flagpoles, trash or leaves blowing over the ground, or the direction the treetops and other landscaping are leaning.

Some even say it’s possible to estimate the way the wind is moo-ving from the way cows are facing (Figure 8, position C). Lore has it that cows (and other tasty herbivores) stand with their tails facing into the wind so they can keep an eye on predators such as feedlot operators who otherwise might approach undetected from downwind, while using their noses to sniff upwind predators that might be behind them. Any such tail-end predators can be dispatched using the on-board methane gas system.

Once you know the wind’s direction, you’ll want to enter the maneuver at a 45 degree angle to the downwind leg (Figure 9, position A), then fly parallel to the perimeter and offset by a quarter to a half mile (I prefer a quarter mile, if possible), as shown in Figure 9, position B. We enter at a 45 degree angle because this is also how we enter the traffic pattern. See how useful this maneuver is already?

Since you will normally first practice this maneuver by making all your turns to the left, a quarter mile offset should place you far enough to the side of the course boundary so
you can easily see it out your left window (Figure 10). When doing this maneuver to the right, you might need just a bit more than a quarter mile offset to identify the course boundary over the right window ledge if you’re in a side-by-side seated airplane, as shown in Figure 11.

Once again, this is very similar to how you’ll fly a traffic pattern at the airport, with the runway (representing one side of the rectangular course) clearly visible out the airplane’s side window (Figure 12). What you don’t want to do is fly directly over the course perimeter, because you don’t (or shouldn’t) have a hole in the bottom of your airplane. Flying directly above the boundary makes it difficult to see the course as well as identify any drift.

On the downwind leg, the wind shouldn’t cause you to drift right or left when no crosswind exists. Then again, as I mentioned earlier it’s sometimes challenging to find the necessary rectangular geometry with boundaries that are exactly parallel and perpendicular to the wind. So it’s possible that you may have to apply a slight wind correction on both the downwind and upwind legs. You make the call here.

**Correcting for Wind Drift**

As you approach the first corner of the course boundary (this will be a turn to the base leg of this rectangular course) and when you are abeam it (when it’s directly off your left side, as shown in Figure 13, position C), begin your turn.

Keep your bank from exceeding 45 degrees—the bank limit for this maneuver—as you turn (Figure 14). The best way to gauge your bank angle during the turn is to cross-check the attitude indicator.
and ensure your bank is 45 degrees or less. As your stick and rudder skills develop, you’ll find that the top of the instrument panel or engine cowling is useful in making an accurate assessment of 45 degrees of bank without having to look inside the cockpit.

Since you’re flying downwind, your groundspeed will be equal to your airspeed plus the wind speed. This higher groundspeed means that you’ll need to use a slightly faster rate of roll-in and a steeper bank to keep from exceeding your previously chosen perimeter displacement of a quarter to a half mile. To better understand this concept, please read the Speed, Rate and Radius sidebar.

As you turn, you’ll want to go at least 10 degrees past the heading that parallels the course boundary. This will be your initial estimate for the wind correction angle (WCA), as shown in Figure 15, position B. Sometimes you’ve just got to make a guess at that WCA and see what happens. That’s right. While there’s no crying in baseball, there is guessing in flying. With experience, your guesses become fairly accurate estimates.

By turning 10 degrees into the wind, you’ve just made a 100 degree turn to the left from the downwind direction (90 degrees plus 10 degrees for drift correction). Now check for airplane drift. If you continue flying parallel to the course boundary, then 10 degrees is a sufficient WCA. Suppose, however, you see that you’re drifting downwind, away from the course boundary. What should you do? Call ATC? Use the autopilot? Scratch your head? Scratch your autopilot?

Clearly, you must apply a larger WCA. How do you do that? You simply make a coordinated turn into the wind. Use your rudder and aileron in coordination to turn a little more into the wind, perhaps an additional 10 degrees. Then roll out of the turn just as you would when rolling out of any other turn. If your WCA is sufficient to correct for wind drift, then you’ll track along a path that’s parallel to the course boundary.

Suppose that the additional 10 degrees causes you to move closer to the course boundary instead of away from it? That means your WCA is a little larger than necessary, right? Apparently a 15 degree WCA would have been the better choice here. So make a coordinated turn to the right of five degrees and roll out. This WCA should allow you to track parallel to the course boundary. If not, then make another small modification to the WCA as appropriate. On the other hand, if you don’t apply a sufficient WCA quickly enough, you’ll drift beyond the quarter to half mile perimeter before finally finding a WCA that works. If this happens, make an even larger wind correction to return to where you should be, followed by resetting to the appropriate WCA.
Chapter 7 - Ground Reference Maneuvers

When abeam the next course boundary (the upwind leg of the rectangular course), you’ll only need to turn approximately 75 degrees to fly parallel to it (Figure 15, position E). Why 75 degrees? Because you’re already heading 15 degrees into the wind, and 90 degrees minus 15 equals 75 degrees. Remember, when heading directly upwind, there should be no need to correct for wind (Figure 15, position F).

Two-and-a-half down, one-and-a-half to go. When you’re abeam the next course boundary (the crosswind leg of the rectangular course), make a shallower banked turn using a heading change of less than 90 degrees (Figure 15, position G). Why less than 90 degrees of turn? Because you want to roll out on a heading that applies the same WCA used on base leg. You’re swimming upstream again.

Unless you’re flying a rectangular course precisely over the middle of a mountain range that disrupts wind flow (and I don’t recommend this), the WCA for the crosswind and base legs should be exactly the same. That means you’ll turn 15 degrees less than 90, or 75 degrees to the left (Figure 15, position H). This leaves you pointing into the wind at a 15 degree WCA, which allows you to fly parallel to the course boundary. Once again, make a coordinated turn to modify your WCA, if necessary.

As you approach the original entry leg of the rectangular course (the downwind leg), you’ll need to turn 105 degrees to align yourself parallel to the course boundary (Figure 15, position I). Why 105 degrees? Because you’re pointed 15 degrees opposite to the direction of turn. In essence, the first 15 degrees just gets you even; you’ve got 90 degrees to go. Adding 15 to 90 gives you 105 degrees of turn.
When abeam the upcoming course boundary (Figure 14, position I), begin your turn and keep in mind that you’re now turning downwind. You won’t have to roll in quite as quickly as you did when making the turn from the downwind to the base leg because you are flying at a slower groundspeed than you were on the downwind leg.

You do, however, have to turn an additional 15 degrees from crosswind to downwind, which requires a bit longer time to execute, so don’t be slow to go. In addition, your groundspeed increases in the turn. Both events require you to use a slightly faster roll-in rate to return to maintain the same course boundary displacement you originally had when you entered this maneuver on the downwind leg.

As you cross the downwind entry point (Figure 15, position J), you’ve passed go and get to collect $200. Ask your instructor for it. Of course, if he just lost his watch, he’ll need that money to purchase a new one.

What’s Important Here?

The rectangular course is the simplest of the ground reference maneuvers. It is also one of the most practical and important to learn. The skills you acquire here can be put to immediate use, especially if you’re planning on landing an airplane. (You have to land, of course. You have to eat and there’s no Chinese takeout—or take-up—in the traffic pattern. If the tower says “lo mein, lo mein” they’re referring to your tire pressure, not your dinner.)

During this and other ground reference maneuvers, you’ll learn to divide your attention between monitoring the ground reference(s) and flying the airplane. That’s easier said than done. It’s also why you’ll initially practice these maneuvers with your flight instructor on board. How do you divide

The Essentials of the Rectangular Course

The physical objective of this maneuver is to maintain a ground track that’s parallel and offset from a rectangular course while correcting for the effect of wind drift.

Why Do We Do it?—The rectangular course uses geometry similar to that used in flying the traffic pattern when approaching to land at an airport, with the sides referred to as the upwind leg, crosswind leg, downwind leg and base leg. The educational objective is to teach you how to anticipate the effect of wind on your airplane with respect to references on the ground as well as to help you learn to divide your attention between flying the airplane and tracking a ground reference.

Ground Reference Needed—You can usually use a traditional city block or a rectangular field (soccer, football) or any rectangular (trapezoidal) ground reference. The ideal is to have each side approximately one mile in length, with the wind parallel to one of the two long sides, but you may have to be creative and adaptable. Sometimes the best you can do is a sub-optimal rectangle where only one side lies at a 90 degree angle to the wind. The desired altitude for the maneuver is between 600 and 1,000 feet AGL.

You will fly one-quarter to one-half mile outside of the selected rectangle.

The Rectangular Course Maneuver, Step-by-Step—

• Enter the maneuver at a 45 degree angle to the downwind leg, then fly parallel to the perimeter and offset by a quarter to a half mile (I prefer a quarter mile, if possible).

• As you approach the first corner of the course boundary (this will be a turn to the base leg of this rectangular course) and when you are abeam it (when it’s directly off your side), begin your turn. As you turn, go at least 10 degrees past the heading that parallels the course boundary. This will be your initial estimate for the wind correction angle (WCA).

• When abeam the upwind leg of the rectangular course, turn to parallel the upwind side of the course, which should take less than 90 degrees of turn given the WCA angle you’re already carrying into the wind.

• When you’re abeam the crosswind leg of the rectangular course, make a shallower banked turn using a heading change of less than 90 degrees. You want to roll out on a heading that applies the same WCA used on base leg.

• As you approach the original entry leg of the rectangular course (the downwind leg), you’ll turn more than 90 degrees to align yourself parallel to the course boundary. You’re turning more than 90 degrees because you’re carrying a WCA into the wind opposite the direction of turn so as to maintain the desired ground track.

• You’ve now come full circle – or full rectangle, to be precise.

Maneuver Notes—

• Figure (15) makes it clear why you sometimes turn more or less than 90 degrees to “turn the corner” and move from one side to another of the rectangle. Your existing WCA either has to be offset and then a 90 degree turn made or the existing WCA has already made part of the 90 degree turn for you.

• If you have been lucky enough to find a rectangle that has the wind exactly parallel to two of its sides, you will not need a WCA when flying downwind and upwind. Most of the time, you will require at least a small correction.

• Keep your bank from exceeding 45 degrees—the bank limit for this maneuver—as you turn. The best way to gauge your bank angle during the turn is to cross-check the attitude indicator and ensure your bank is 45 degrees or less. As your stick and rudder skills develop, you’ll find that the top of the instrument panel or engine cowling in useful in making an accurate assessment of 45 degrees of bank without having to look inside the cockpit.

• The rate at which you roll into your turns is a function of groundspeed. When going downwind, you’re moving fast (airplane speed + wind speed) so you need to bank faster and harder when turning crosswind. When turning from crosswind to upwind, your groundspeed is slowing as the turn progresses, so you need to roll into the turn slower and use a shallower bank angle. Remember, it’s ultimately about your track over the ground.
your attention? You simply divide your attention. You look outside for a bit, check the ground reference, then glance back inside the airplane to ensure that the altitude, airspeed, heading and so on are appropriate. It’s the same principle as cross-checking a flight instrument that we discussed in an earlier chapter. The difference being that instead of looking at the horizon, you’re looking primarily at the ground and the horizon as you occasionally glance at your flight instruments.

The challenge in dividing your attention is that you’ll often forget the divide part (especially if you weren’t good at math). You might find yourself looking outside and staring almost exclusively at the ground while your airplane and altitude take a nosedive. After just a little practice, most pilots get the idea about dividing their attention. From then on they find it much easier to attend to both the ground reference and the airplane.

As an aside about outside, you should spend most of your time looking outside the airplane. During ground reference maneuvers, you’ll probably spend 70% of your time looking at the ground reference and 30% of the time looking inside the cockpit. Pilots with experience typically spend about 17% of their time looking inside the cockpit. Spending a bit larger chunk of time looking inside the cockpit is reasonable for anyone new to ground reference maneuvers, given the need to maintain specific airspeed, bank and altitude requirements. With practice, however, the in-cockpit head time can be steadily reduced.

Now here’s a perfect way to put your computer to use as a student pilot. Why not install Google Earth and use it to find the perfect ground reference for your maneuvers before you practice them? It’s free and you can use the features of Google Earth to drop a pin over areas that would be suitable for each different type of ground reference maneuver you’ll do.
**Turns Around a Point**

*Turns around a point* sounds like something a ballerina would do. For you as a pilot, *en pointe* means something a bit different. The *physical objective* of this maneuver is to make the airplane fly a constant radius around a specific point on the ground by correcting for the effects of wind while not exceeding a bank angle of 45 degrees during this maneuver. (Figure 16).

The *educational objective* of this maneuver is to teach you how an airplane’s radius of turn is affected by both the airplane’s bank angle and the wind’s speed and direction. It helps you develop a good sense of your altitude above ground level as well as furthering your development at subconscious control of the airplane while your attention is diverted to references outside the airplane.

This maneuver combines turning and correcting for wind drift while a constant radius of turn is maintained around a prominent and easily identified ground reference. The nice thing about it is that you already know how to do it...well sort of. Think of this as a round rectangle. Let others circle the wagons; you’re going to circle the point.

Turning around a point and flying a rectangular course are essentially the same maneuver with the right angles of the rectangular course removed. This is shown by the progressive rounding of the rectangular corners as shown in Figure 17. Now the four legs of the rectangular course (downwind, base, upwind and crosswind legs) are represented by four positions located at 90 degree intervals around the circle.

The only difference between the rectangular course and turns around a point is that the airplane must be kept banked at some angle throughout this maneuver in order to maintain the correct turn radius. You can directly apply to performing turns around a point what you learned in navigating a rectangular course.

**Fig. 16**

**Turns Around a Point**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant radius maintained around center point</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enter the maneuver by flying downwind</td>
<td></td>
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**Fig. 17**

**Similarities Between Maneuvers**

Round off the edges of the rectangular course and you get the same “leg” positions in the newly morphed turns around a point.
As was the case with the rectangular course, if there is no wind this is a very easy ground reference maneuver to perform. You’d simply fly a circular path around the point at a constant bank angle and be done with it. But how often is that going to happen? When pigs get instrument ratings. Wind affects ground-speed and drift, requiring continuous re-calculation of bank angle and wind correction angle. For wind of the same direction and velocity, the maximum wind correction angles used when turning around a point are essentially the same as those used for the rectangular course. In other words, if you needed a 15 degree WCA to remain parallel to the base leg in a rectangular course, you’ll also need a 15 degree WCA to maintain the correct radius of turn at the 90 degree point when turning around a point. The only significant difference here is that you’re constantly banking to some degree in order to fly a constant radius around the chosen point. Let’s take a closer look at how to perform this maneuver.

Before we can begin this maneuver, there’s an important point to be made. Or rather, found. You need to find a nice point about which to turn. The point can be an intersection, a tree, an outhouse or anything else that’s readily visible and relatively pointy. The preferred altitude for this maneuver is between 600 and 1,000 feet AGL, with my personal preference being lower, perhaps at 600 feet AGL. This makes the effects of wind drift more apparent.

Begin this maneuver by flying downwind (Figure 16) at a distance from the point equal to the radius at which you want to fly the maneuver. Keep in mind that the chosen radius should allow you to fly the maneuver and correct for the effects of wind without exceeding 45 degrees of bank at the steepest part of this maneuver. The big question is how far from the reference should you make your initial entry. You can make a good approximation by entering just far enough to the side of the reference point so that it’s halfway between the wing tip and the main gear (Figure 18). This will keep you from exceeding 45 degrees of bank but place you in a good position to begin the maneuver.

If you’re in a high wing airplane and you choose a radius that’s too far from the ground reference during entry to the maneuver your wing will block your view of the reference during the steepest portion of the turn (Figure 19, position 1). This isn’t the end of the world (that typically involves a lot of water or a very big flash of some sort), but it’s nice to see the reference all the time, if possible. If you’re in a low wing airplane and choose a radius of turn that is too small, it’s possible that your wing will also block the reference during a portion of the turn (Figure 19, position 2).
As you enter the maneuver downwind, begin your turn (left, in this instance) when you’re abeam the chosen ground reference, as shown in Figure 20, position A (it’s best to do all ground reference maneuvers to the left the first time you do them. The view is always better out your left window). At this point, you’ll be flying at maximum groundspeed. This is also the place where you’ll need to apply the maximum bank to maintain the correct radius of turn. Roll crisply into the appropriate bank angle (try some bank angle less than 45 degrees at first). Then be willing to increase or decrease the bank angle as necessary to maintain the selected turn radius. That’s right. You gotta know when to hold ‘em and know when to roll ‘em when it comes to the bank angle, and that means changing the bank as needed to keep the turn radius constant.

As the turn progresses beyond your initial entry and toward 90 degrees of turn (Figure 20, position B), you’ll have to gradually reduce the bank angle as groundspeed decreases (the wind is no longer from directly behind you as you continue to turn, so your groundspeed is decreasing).

As you progress toward 90 degrees of turn, you also need to progressively apply a slight WCA to maintain the turn radius. Here is where you’ll allow the airplane’s nose to continue turning a little beyond or inside the imagined circular ground path, to keep from stretching the downwind portion of the turn (Figure 21, position B).

Turning inside your imagined circular ground path is the equivalent of applying the same WCA used when flying a rectangular course with similar winds. You accomplish this by gradually reducing the bank angle when approaching 90 degrees of turn, but not so fast that the nose turns parallel to or outside the imagined turn arc. This keeps the nose turned slightly inside the desired ground track
Chapter 7 - Ground Reference Maneuvers

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arc. This is how you can crab into the wind during the turn while keeping the rudder and aileron perfectly coordinated. Now your radius of turn is constant, which is another way of saying that your ground track is circular.

Continuing the turn past the 90 degree point toward 180 degrees of turn, you’re now heading upwind. This means your groundspeed continues to decrease (Figure 22). You must progressively reduce the bank angle to maintain the correct turn radius. At the 180 degree of turn point (Figures 22 and 23, positions C), your groundspeed is the lowest it will be during the entire maneuver and the bank angle is also the smallest. That should make sense, since you’re not flying as fast and you don’t need to turn as fast to circle the reference point. At 180 degrees of turn you’re pointed directly into the wind, so there should be no wind correction angle applied. This is why your left wing is directly in line with the ground reference point.

How to Divide Your Attention Between Airplane and Ground

Dividing your attention between the cockpit and some outside reference is a learnable behavior that involves time-sharing your conscious attention between two things. Here’s how you do that.

You typically begin a ground reference maneuver by placing your airplane abeam a ground reference. As you commence maneuvering, you’ll initially need to focus your attention outside the cockpit. Once you are established in the initial attitude around or about the ground reference, return your attention to the instrument panel, ensuring that the airplane is in the required pitch and bank attitude needed to sustain that maneuver.

For example, suppose you’re downwind and ready to begin the initial turn for the maneuver known as turns around a point. You enter the maneuver by looking at the ground reference, then rolling into a steep turn at or below 45 degrees of bank while simultaneously holding altitude. As you glance back at your instrument panel, you need to ensure that the altimeter needle isn’t moving and that the attitude indicator shows less than 45 degrees of bank. There’s no need to look at the heading indicator or any other instrument that doesn’t provide you with immediately actionable information. That’s why knowing what instruments you need to look at as you return to the panel is absolutely essential in minimizing the time spent with your head in the cockpit.

While looking back at the panel, any deviation in bank, altitude or airspeed (or whatever performance value is essential here) should be immediately corrected with a slight change in attitude or power, followed by returning your attention to the ground reference. Most of your conscious attention should be focused outside the airplane, not on the instrument panel.

Keep in mind that a change in altitude is often the immediate result of a failure to monitor the airplane’s attitude. When you shift your attention back to the panel, the altimeter should be your eyes’ first stop. Then it’s back to ground.
As you approach the upwind point of the circle (the 270 degree turn point), as shown in Figure 24, position D, your groundspeed begins to increase slightly because the wind is no longer blowing directly on your nose. You’ll have to increase the bank slightly to maintain the correct turning radius. However, you’ll also need to keep the airplane’s nose pointed slightly outside your imagined circular ground track in order to keep your turn radius from decreasing. Apply the same WCA you used at the 90 degree of turn point (the WCA won’t change much and if it does change a little, that’s due to slight changes in airspeed due to bank angle).

How do you do that? Gradually increase the bank angle to compensate for the increasing groundspeed but not so fast as to pull the nose parallel to or inside the imagined turn arc (Figure 25, position D). In

**Turns Around a Point - Graphically Explained**

Sometimes there’s nothing like a good graph to help you make sense of a particular maneuver. So let me help you understand how to use the *Turns Around a Point* graph to the right.

On the left side of the graph are three vertical color coded bars representing the wind correction angle, the groundspeed and the bank angle used in this maneuver. The top of these bars represent maximum values (MAX) while the bottom represents minimum values (MIN).

The graph’s horizontal axis represents the degrees of turn throughout the maneuver. Position A represents the beginning and end of the maneuver (0° and 360° of turn) where the groundspeed and the bank angle are the largest (MAX). At positions B and D (90° and 270° of turn) the wind correction angle is at a maximum and the groundspeed and bank angle are approximately half of their max value. At 180° of turn all three values are at a minimum.
other words, increase the bank angle during the 180-to-270 degree turn, but do so slower than your untrained intuition tells you to. This will keep the nose pointed slightly outside the desired circular ground track.

At and beyond the upwind or 270 degree point (Figure 26, position D) of the turn, your bank should increase as the groundspeed increases. You’ll reach the maximum bank at the 360 degree point (Figure 26, position A), which is where this maneuver first began. As you can see from Figures 26 and 27, you’re headed directly downwind and your groundspeed is at a maximum and no wind correction angle is needed.

Welcome home. Now keep going! That’s right. Don’t stop at one turn. Continue this maneuver for at least two full turns as a demonstration of your skill.

Why do we practice this maneuver? The first and most important reason is that it furthers your understanding how the wind affects an airplane. Believe me when I say that you can never have too much understanding of what wind does to a flying machine. Comprehending how wind affects the airplane is essential in predicting your airplane’s flight track geometry. You absolutely need to have this skill if you hope to land in a crosswind. And I hope you do. Being able to land only when the wind is right down the runway is very limiting.

The additional value in this maneuver is that it helps you learn how to divide your attention between looking outside and inside the cockpit. If you keep gaining or losing altitude while turning, you haven’t yet mastered how to divide your attention properly. It shouldn’t be much of a surprise to learn that good pilots spend a lot of time looking outside the cockpit. This is a major reason why we fly, isn’t it? It’s all about the view and avoiding other aircraft in the process. So anything you learn that helps identify when the attitude of the airplane changes is a worthwhile skill to have.

Turns around a point help you better understand how altitude can vary with the slightest diversion of attention, which is a dangerous proposition when close to the ground. Take a look at the sidebar *Turn Around a Point - Graphically Explained* the left for a graphic idea about how wind correction, groundspeed and bank angle interrelate during the performance of turns around a point.
The Essentials of Turns Around a Point

The physical objective of this maneuver is to make the airplane fly a constant radius around a specific point on the ground by correcting for the effects of wind while not exceeding a bank angle of 45 degrees during this maneuver.

Why Do We Do It?—The educational objective of this maneuver is to teach you how an airplane’s radius is affected by both the airplane’s bank angle and the wind’s speed and direction. It helps you develop a good sense of your altitude above ground level as well as furthering your development at subconscious control of the airplane while your attention is diverted to references outside the airplane.

Ground Reference Needed—The point can be an intersection, a tree, an outhouse or anything else that’s readily visible and relatively pointy. The preferred altitude for this maneuver is between 600 and 1,000 feet AGL.

Turns Around a Point, Step-by-Step—

- Begin this maneuver by flying downwind at a distance from the point equal to the radius at which you want to fly the maneuver.
- As you enter the maneuver downwind, begin your left turn when you’re abreast the chosen ground reference.
- If you progress toward 90 degrees of turn, you also need to progressively apply a slight WCA to maintain the turn radius.
- Continuing the turn past the 90 degree point toward 180 degrees of turn, you’re now heading upward with your groundspeed decreasing (Figure 22). You must progressively reduce the bank angle to maintain the correct turn radius.
- At the 180 degree of turn point, your groundspeed is the lowest it will be during the entire maneuver and the bank angle is also the smallest.
- As you approach the upwind point of the circle (the 270 degree turn point), you’ll progressively apply a WCA. As you turn away from a direct headwind, your groundspeed begins to increase and you’ll have to increase the bank slightly to maintain the correct turning radius.
- As you enter the maneuver downwind, begin your left turn when you’re abreast the chosen ground reference.
- As you progress toward 90 degrees of turn, you also need to progressively apply a slight WCA to maintain the turn radius.
- At the 180 degree of turn point, your groundspeed is the lowest it will be during the entire maneuver and the bank angle is also the smallest.
- Approaching the upwind point of the circle (the 270 degree turn point), you’ll progressively apply a WCA. As you turn away from a direct headwind, your groundspeed begins to increase and you’ll have to increase the bank slightly to maintain the correct turning radius.
- At and beyond the upwind (270 degree) point of the turn, your bank should increase as the groundspeed increases. You’ll reach the maximum bank at the 360 degree point, which is where this maneuver first began.

Maneuver Notes—

- Turning around a point and flying a rectangular course are essentially the same maneuver with the right angles of the rectangular course removed (Figure 17).
- If you’re in a high wing airplane and you choose a radius that’s too close to the ground reference, your wing will block your view of the reference during the steepest portion of the turn.
- If you’re in a low wing airplane and choose a radius that is too large, it’s possible that your wing will also block the reference during a portion of the turn.
- Turning inside or outside your imagined circular ground path is the equivalent of applying the same WCA used when flying a rectangular course with similar winds.
- A critical part of this maneuver is the initial bank used when entering downwind. You’re moving fast in this position and it’s easy to be blown downwind of the ground reference if the initial bank isn’t steep enough. If you entered the maneuver upwind, then things would happen more slowly and you’d have more time to modify your bank. So be prepared to modify the bank quickly if it doesn’t produce the desired turning radius.
- The crab into the wind in Figure 20 is applied by turning just a tiny bit faster (i.e., increasing your bank angle) than you normally would if you were flying this arc in a no-wind condition.
- The crab into the wind in Figure 24 is applied by turning just slow enough to keep the nose pointed outside the imagined turn arc.

S-Turn Across a Road

Now we come to a ground reference maneuver that’s essentially a turn around a point on a half shell (or two). In other words, it the same maneuver but sliced in half and set side-by-side (Figure 28).

The physical objective of this maneuver is to fly half circles of equal radii along a straight ground reference line (such as a road, fence or field border) at 600 to 1,000 feet AGL. The educational objective of this maneuver is to teach you how an airplane’s radius is affected by both the airplane’s bank angle and the wind’s speed and direction. It helps you develop a good sense of your altitude above ground level as well as furthering your development at subconscious control of the airplane while your attention is diverted to references outside the airplane. S-turns across a road is more demanding of the pilot than turns around a point, mainly because of the alternating right and left hand turns experienced throughout the maneuver.

The ground reference line is chosen so that it’s perpendicular to the wind’s direction, which allows you to apply the same principles learned from performing turns around a point. The only real difference between this maneuver and turns around a point is that each side of the half circle is flown in a different direction instead of using only a right or left bank for the entire maneuver.

I prefer to introduce this maneuver after introducing turns around a point because it’s a slightly more challenging maneuver to learn. Why? Because you’re correcting for wind drift while turning and following a road at the same time. Complicating matters is the requirement to alternate from right turns to left turns. Additionally, this maneuver requires you to keep in memory the size of your previous half-circle’s radius as well as imagin-
Chapter 7 - Ground Reference Maneuvers

S-Turns Across a Road

The objective of this maneuver is to fly half circles of equal radii (R) along a road (or any straight ground reference). The same principles you learned in flying turns around a point also apply to S-turns across a road.

The only difference between this example and flying an S-turn across a road you have to imagine the half circle.

A Slightly Different Explanation as to How the Airplane Crabs Into the Wind When Flying S-turn Half Circles

Let’s suppose you were instructed to fly your airplane above and along a large green arc painted onto the ground from positions A to E (Insert #1). In a no wind condition, you only need to keep the airplane’s nose (OK, its longitudinal axis) pointed in the same direction of the curving arc to remain directly above and over it. If you tried to keep the nose directly over and precisely aligned with the curving arc when wind is present (Insert #2), your airplane would be blown to the outside of the arc (or to the inside with a reversed wind).

For example, when flying from position F to J while attempting to keep the nose aligned with the green arc while flying directly above it, you would be blown to the outside of the arc (position Z). Now you need to turn back toward the arc to intercept it again at position G. Therefore, instead of letting yourself be blown to the outside of the arc to begin with, you should begin your turn at position F and purposely bank the airplane so that the nose initially points just to the inside of the green arc. This is how you crab into the wind to maintain a half-circle ground track. If there were actually a green arc on the ground, then you’d need to turn so as to increase the angle between the arc (into the wind) as you progress to position H (where the maximum crab angle occurs). And, of course, you’d need to decrease this crab angle between positions H and J. The only difference between this example and flying an S-turn across a road you have to imagine the half circle.
Enter this maneuver downwind, perpendicular to the road (A). The steepest bank occurs as the road is crossed (B). From B to D, the bank angle is gradually reduced as the groundspeed decreases while the wind correction angle gradually increases. The max WCA occurs at point D. Bank angle continues to decrease from D to F while the WCA also decreases. Cross the road in wings-level flight and continue the turn in the opposite direction.

Enter the maneuver by flying downwind (Figure 29, position A), crossing the road at a 90 degree angle. The moment you are directly above the road begin a right or left turn (Figure 29, position B). Your objective is to fly a half circle at a constant radius. How big a radius? Well, that’s for you to decide, but it shouldn’t be so small that it requires use of more than 45 degrees of bank (even in a strong wind). Ultimately, the radius is determined by the perceived distance from the road. This is where you need to develop an ability to estimate distances and retain this estimate in your short term memory. That’s why this maneuver is best practiced after turns around a point (and, perhaps, with a quick shot of Ginkgo biloba, too).

Everything you learned performing turns around a point is applicable here. You already know how to do this maneuver, but you only have to do half of it, then switch directions to complete the other half. If this were a date, you could rightly claim that your partner is a big tease. After all, you get halfway through your maneuver and things are going well, then you’re forced to stop and change directions.

The rate of roll-in and the steepest bank occur at the point where you begin the downwind turn (position B). Approaching 90 degrees of turn, you’ll need to be crabbed into the wind to maintain your circular ground track (positions C to D). Do this the same way you did it when performing turns around a point—by continuing the turn toward the inside of the imaginary circular ground path as you approach the 90 degree turn point (position D). This keeps you from being blown downwind, outside the desired circular ground track.

Think about it this way. If you were flying this maneuver in a no wind condition, your airplane’s nose would always point in the same direction as the half-circle ground track. With wind, however, expect that the airplane’s nose should always be turned (crabbed) a bit toward the inside of the circular ground track on the downwind loop, and toward the outside on the upwind loop. This means that you have to turn just a little bit faster than you normally would if you were flying this maneuver.
in a no-wind condition. You’ll find that you need a moderate bank at position D in Figure 29 along the turn (the 90 degree point), with the bank angle and the wind correction angle continuing to decrease as you approach the 180 degree of turn point (position F).

At 180 degrees of turn (Figure 29, position F), your wings should be temporarily level (0 degrees of bank) as you roll into a turn in the opposite direction. The object is to make the same size half circle that you made on the downwind portion of this maneuver. Be careful here, because you’re heading into the wind and your groundspeed is at its slowest at position F. If you roll into a bank too quickly or use too large a bank angle at this point, the turning radius on this upwind circle will be smaller than on the downwind circle.

From positions F to H in Figure 30, you’re applying a moderate amount of bank and the airplane’s nose is pointed outside of the circling path to establish a WCA into the wind. Once again, the crab into the wind was applied by not turning as fast as you normally would if you were flying this arc in a no wind condition. In other words, your rate of turn up to position H is slow enough to allow the nose to point slightly outside the circular path you’re making along the ground.

At position H, the airplane begins to turn with the wind, thus rapidly increasing your groundspeed. The bank angle must also increase if you want to maintain the same circling radius. When reaching position J (180 degrees of turn), groundspeed is once again at its maximum and your bank angle is at a maximum just before you cross the road. As you cross the road, your wings should transition though level flight as you roll from one turn to the next, repeating the maneuver as you travel along the road. Figure 31 shows this maneuver in graphic format. S’good.

The graphic representation of this maneuver shows that the max and min values of WCA, groundspeed and bank angle occur at the same place they occur when performing turns around a point.
The Essentials of S-turns Across a Road

The physical objective of this maneuver is to fly half circles of equal radii in opposite directions along a straight ground reference line (such as a road, fence or field border) at 600 to 1,000 feet AGL.

Why Do We Do it?—

S-turns across a road combine two important elements of flight that you’ll often use when operating with reference to the ground: turning while correcting for wind drift. It develops your ability to follow a desired ground track when the WCA is constantly changing. Your ability to fly while managing the distractions of a ground reference is also developed.

Ground Reference Needed—

You’ll need a straight ground reference—a road, railroad tracks, a row of corn, the edge of a farmer’s field, or even a reasonably straight river or stream that’s perpendicular to the wind’s direction.

S-turns Across a Road, Step-by-Step—

• Enter the maneuver by flying downwind, crossing the road at a 90 degree angle. The radius is determined by the perceived distance from the road.
• Approaching 90 degrees of turn, you’ll need to be crabbed into the wind (toward the inside of the half-circle) to maintain your circular ground track.
• At 180 degrees of turn, your wings should be temporarily level (0 degrees of bank) as you begin an immediate turn in the opposite direction.
• Approaching 90 degrees of turn in the opposite direction, you’ll need to be crabbed into the wind (toward the outside of the half-circle) to maintain your circular ground track.
• As you cross the road again, the wings should be level with the airplane rolling into a turn in the opposite direction until told by your instructor or examiner that the maneuver is complete.

Maneuver Notes—

• The half-circle turn radius shouldn’t be so small that it requires use of more than 45 degrees of bank when flying downwind (even in a strong wind).
• The rate of roll-in and the steepest bank occur at the point where you begin the downwind turn.
• If you were flying this maneuver in a no wind condition, your airplane’s nose would always point in the same direction as the half-circle ground track.
• The object is to make the same size half circle that you made on the downwind portion of this maneuver.
• On the downwind loop, the crab into the wind is applied by turning just a tiny bit faster (i.e., increasing your bank angle) than you normally would if you were flying this arc in a no-wind condition.
• On the upwind loop, the crab into the wind is applied by not turning as fast (i.e., decreasing your bank angle) as you normally would if you were flying this arc in a no-wind condition.
• At 180 degrees of turn the airplane should be passing through wings level flight while rolling smoothly from one bank to another as you cross the ground reference.
• After 90 degrees of turn (while turning into the wind) your closure rate with the road decreases, thus you must reduce your bank accordingly or you’ll be perpendicular with the road before crossing it.
• After 270 degrees of turn (while turning with the wind) your closure rate with the road increases, thus you must increase your bank accordingly or you’ll cross the road at some angle less than 90 degrees.
• The bank in this maneuver is constantly changing when wind is present.
• There’s a general tendency to increase the bank too quickly when turning from 90 to 180 degrees, thus completing the 180 before crossing the road.
• The secret to performing this maneuver correctly is to visualize the circular ground track desired on both the upwind and downwind half-circles.
• Since the evaluation of half-circle ground tracks can be somewhat subjective, an emphasis is placed on a pilot’s ability to arrive over the road in wing’s level flight as a means of evaluating his performance in this maneuver.

Positive Exchange of Flight Controls

When one pilot wishes to give the flight controls of the airplane to another pilot, he or she should use the following protocol:

1. “You have the flight controls.”
2. “I have the flight controls.”
3. “You have the flight controls.”

The other pilot should acknowledge this immediately by saying:

The first pilot should say again,

This is a very important procedure to follow every time another pilot wants to use the controls, especially on your pilot checkride. It’s an excellent way of always knowing who’s flying the airplane.
Chapter 7 - Ground Reference Maneuvers

Eights Along a Road

The first three ground reference maneuvers we’ve studied are the ones you’re required to know for your private pilot checkride. The next few maneuvers aren’t required for you to become a private pilot, but they’re well worth knowing so that you can improve your piloting skills and become an exceptional private pilot. In most cases, they are simply differing combinations and permutations of what you’ve already done.

The educational objective of this maneuver is similar to other ground reference maneuvers in that it helps you develop your skill compensating for wind drift while turning with respect to a ground reference. It also helps you develop a good sense of your altitude above ground level as well as furthering your development at subconscious control of the airplane while your attention is diverted to references outside the airplane. The physical objective of this maneuver is to fly a ground track consisting of two complete circles adjacent to each other having equal radii on each side of a road with that road oriented perpendicular to the wind (Figure 32). Looked at from above or below, the maneuver appears to inscribe the figure of an “8” on the ground or in the air, respectively.

Sure, while you’re up there doing this maneuver you’ll look like a skywriter who’s writing with invisible ink. But with a little imagination, observers might see the eight (especially during Octoberfest or an Eighth of July party). This maneuver uses the same skills used in turns around a point and S-turns across a road.

Begin the maneuver by flying directly along a road (or field boundary, or tree line and so on) oriented perpendicular to the wind. This means you’ll have a wind correction angle already applied to track the road (Figure 32, position A) prior to beginning the maneuver. Remember the size of this WCA. When you come to an intersection or some definable reference on the surface (obviously not...
a car that’s moving), start the right turn (or left, depending on your preference for entering the maneuver) and begin the downwind circle (Figure 33, position B). As with all circling ground reference maneuvers, turning downwind means that your groundspeed is increasing, and that requires a quick roll-in, reaching the maximum bank angle to be used at position C. Initially, you’ll have to do your best to estimate this bank angle but 40 to 45 degrees of bank is a good angle to use in the absence of other information. You can always reduce the bank if it appears to be too steep.

When reaching 90 degrees of turn on the downwind portion of the circle (position C), your groundspeed and bank angle are at a maximum and the wind correction angle is zero. Continuing past this position, begin reducing the bank just slow enough so that your nose turns a little beyond or inside your imaginary circular ground track on the downwind side of the circle. This is how you apply a wind correction angle (and crab into the wind) on the downwind portion of this arc, thus preventing a distortion (stretching) of the circling path. At the 180 degree turn point (position D), you’ll have the maximum wind correction angle applied toward the inside of the circular path using a moderate bank, and the groundspeed will be decreasing. As you continue the turn to 270 degrees and head into the wind, the bank continues to decrease commensurate with the decreasing groundspeed. At the 270 degree turn point, the wind correction angle is zero and groundspeed is at its minimum for this maneuver (position E).

Continuing beyond 270 degrees of turn, strive to cross the road at the same starting point used when entering this maneuver. Ideally, you’ll also cross it at the same WCA used during your initial track before beginning the first downwind loop. This means making the corrections necessary to cross the road in a wings level attitude at the original WCA then immediately entering a turn in the opposite direction to begin the upwind loop of this maneuver (position B).

Since you’re now turning left, into the wind, groundspeed is decreasing so you won’t need to use as steep a bank to begin the upwind loop as you did when turning downwind. At the 90 degrees of
The Essentials of Eights Along a Road

Eights along a road (or a fence or a field border or any straight line reference) consists of two adjacent circles flown on each side of a road that’s oriented perpendicular to the prevailing winds (Figure 33). Looked at from above or below, the maneuver appears to inscribe the figure of an “8” on the ground or in the air, respectively.

Why Do We Do It?—The educational objective of this maneuver is similar to other ground reference maneuvers in that it helps you develop your skill at compensating for wind drift while turning with respect to a ground reference. It also helps you develop a good sense of your altitude above ground level as well as furthering your development at subconscious control of the airplane while your attention is diverted to references outside the airplane.

Ground Reference Needed—You’ll need a road or reference boundary that’s aligned perpendicular to the wind. An altitude between 600 and 1,000 feet AGL is the desired altitude for the maneuver.

Eights Along a Road, Step-by-Step—
- While flying parallel to a road and perpendicular to the wind, begin a right or left turn to start the downwind circle when you come to an intersection or some definable reference on the surface (obviously not a car that’s moving).
- Don’t exceed 45 degrees of bank at the steepest part of the maneuver (when flying the downwind portion of any circle).
- When reaching 90 degrees of turn on the downwind portion of the circle, your groundspeed is at its maximum, the wind correction angle is zero and your bank is at its maximum.
- Continuing past 90 degrees of, begin reducing the bank just fast enough so that your nose turns a little beyond or inside your imaginary circular ground track on the downwind side of the circle.
- At the 180 degree turn point, the wind correction angle is zero and the bank angle is at a minimum for this maneuver.
- As you continue the turn to 270 degrees and head into the wind, the bank continues to decrease commensurate with the decreasing groundspeed.
- At the 270 degree turn point, the wind correction angle is zero, the groundspeed is at its minimum and the bank angle is at a minimum for this maneuver.
- Continuing beyond 270 degrees of turn, strive to cross the road at the same starting point used when entering this maneuver.
- When entering this maneuver, ideally you’ll also cross it at the same WCA used during your initial track before beginning the first downwind loop.
- Now begin a turn in the opposite direction, into the wind, where the groundspeed is decreasing. You won’t need to use as steep a bank to begin the upwind loop as you did when turning downwind.
- The same techniques apply on the upwind loop except that to maintain the circular ground track, you must increase your bank angle just fast enough to allow the airplane’s nose to point outside the imagined circling path, thus providing the necessary WCA to maintain a circular ground track.

Maneuver Notes—
- You apply a wind correction angle (and crab into the wind) on the downwind portion of the arc by turning fast enough so that your nose turns a little beyond or inside your imaginary circular ground track on the downwind side of the circle.
- There’s no reference point at the middle of the circle by which you can gauge your radius of turn. So you must visualize the circular ground track being flown. There’s no reference point at the middle of the circle by which you can gauge your radius of turn, either. So there is a certain amount of subjectivity as to whether or not your circle is another man’s ellipse. That’s why arrival over the road at the same starting point and in a wing’s level attitude becomes even more important as a means of evaluating your proficiency with this maneuver.
- Ultimately, it’s your arrival over the road at the same starting point and in a wing’s level attitude that offers the best means by which to evaluate your proficiency with this maneuver.
- Since the evaluation of the circular ground track is a bit more subjective in this maneuver than with S-turns across a road, the emphasis is placed on a pilot’s ability to arrive over the road in wing’s level flight as a means of evaluating his performance in this maneuver.

turn point (position F), your groundspeed will be at a minimum. To maintain the circular ground track beyond position F, begin increasing the bank just fast enough so that the airplane’s nose points to the outside the circling path, thus providing the necessary WCA to maintain a circular ground track. When reaching the 180 degree turn point on the upwind loop (position G), the WCA should be at a maximum.

Turning beyond position G to the 270 degree turning point, groundspeed will now be increasing. This requires an increase in the bank and rate of turn. The maximum bank will be achieved at 270 degrees of turn as you’re flying directly downwind (position H).

Beyond the 270 degrees of turn point, maneuver to cross the road at the same point where you began this maneuver. Done correctly, you’ll actually turn to cross the road with the nose pointed upwind (into the wind) slightly, which is nothing more than the WCA (also turn to cross the road with the nose pointed upwind slightly , which is nothing more than the WCA (Figure 33)). Looked at from above or below, the maneuver appears to inscribe the figure of an “8” on the ground or in the air, respectively.

As with all our ground reference maneuvers, this one requires a division of attention between flying the airplane and maintaining a circular flight path along the ground. This maneuver takes the level of difficulty up a notch because you have to visualize the circular ground track being flown. There’s no reference point at the middle of the circle by which you can gauge your radius of turn, either. So there is a certain amount of subjectivity as to whether or not your circle is another man’s ellipse. That’s why arrival over the road at the same starting point and in a wing’s level attitude becomes even more important as a means of evaluating your proficiency with this maneuver.

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Eights Around Pylons

If you’re interested in improving your ground reference maneuvering skills, you might want to elevate your plane game a bit more by practicing *eights around pylons*. I once taught a ground class to eight students, and when I said that, they all *piled on* (OK, that didn’t happen but I could see it in their eyes). Dangerous business, instructing.

The *educational objective* of this maneuver is to use skills learned during the practice of other ground reference maneuvers. Skills such as wind drift assessment and correction, altitude assessment and the ability to fly with your attention diverted to the outside of the airplane.

The *physical objective* of this maneuver is essentially to make circular ground tracks around two different points or pylons in opposite directions while compensating for the effects of wind. From the ground looking up, or the air looking down, this maneuver appears to make the shape of the number eight, as shown in Figure 34 (thank goodness we don’t use Roman numerals any more because who could fly something that looks like VIII? Hey, let’s do the “V with the three bars” maneuver. What?). This maneuver also requires a lot less subjective evaluation than eights along a road. That’s because you’re trying to maintain a circular path at a constant radius about two distinct points on the ground. You also don’t need to learn anything new here since this maneuver uses only the skills you’ve learned previously.

Eights around pylons tests your ability to perform two “turns around a point” in different directions. Your ability to perform them correctly demonstrates your skill at maneuvering right and left while your attention is diverted outside the airplane.
Chapter 7 - Ground Reference Maneuvers

The first thing you want to do is to choose two pylons or ground references oriented perpendicular to the prevailing wind direction. These pylons can be trees, road intersections or any two objects that can be easily seen from at least 600 feet AGL (it’s perfectly legal to do this maneuver at 500 feet AGL as long as you meet the minimum altitude requirements in the FARs). Since this maneuver is more advanced than the previously discussed ground reference maneuvers, an altitude of 500 feet AGL increases the skill necessary to pull it off. Why? Because when you’re lower, things happen a lot faster, thus requiring more planning and skill on your part (see sidebar below).

You’ll begin by flying downwind between the pylons to enter either a right or left turn (we’ll enter a right turn in our demonstration), as shown in Figure 34, position A. This maneuver is nothing more than two individual turns around a point that are placed side-by-side. You fly from a turn in one direction to a turn in another direction (Figure 34 Insert, position Z). As Figure 34 shows, to maintain your selected turn radius, the steepest bank is required when flying downwind (position B) and the shallowest bank when flying upwind (positions D and G). Everything you’ve learned when doing turns around a point applies and should be applied here.

On the upwind and downwind crosswind portions of the loops (positions C, E, F and H), you’ll still need to apply the appropriate WCA to make your ground path circular. There’s nothing new here except for the change in direction when completing one portion or one half of the eight. At this point, you immediately roll into a bank in the opposite direction to fly a circular track of similar radius.

**Why Things Appear to Move Faster When You’re Closer to the Ground**

It should be no big secret to you that the closer you are to any moving object, the faster it appears to move. Seeing a jet moving overhead at 30,000 feet and 500 mph is a very different thing than seeing the same jet fly overhead at 300 feet. The jet appears to move through your field of vision faster when it’s closer to you, which we tend to associate with an increase in speed.

This is one reason why *eights around pylons* is practiced at 500 feet AGL. The intent of this maneuver is to increase your skill level beyond that already gained by performing rectangular courses, *turns around a point* and S-turn across a road. This is why you typically practice eights on pylons after (and not before) you’ve learned the previous three ground reference maneuvers.

**The Essentials of Eights Around Pylons**

The physical objective of this maneuver is essentially to make circular ground tracks around two different points or pylons in opposite directions while compensating for the effects of wind. Done properly, the resulting ground track resembles a figure 8.

**Why Do We Do It?**—The educational objective of this maneuver is to use skills learned during the practice of other ground reference maneuvers. Skills such as wind drift assessment and correction, altitude assessment and the ability to fly with your attention diverted to the outside of the airplane.

**Ground Reference Needed**—Choose two pylons or ground references oriented perpendicular to the prevailing wind direction. These pylons can be trees, road intersections or any two objects that can be easily seen from at least 500 feet AGL (the optimal altitude to use for this maneuver as long as it’s legal from an FAR perspective of minimum altitudes).

**Eights on Pylons, Step-by-Step**

- Establish the desired distance from the pylon in the same way you did during turns about a point.
- Start the eight on a downwind heading while passing between the pylons.
- You fly from a turn in one direction to a turn in another direction.
- To maintain your selected turn radius, the steepest bank is required when flying downwind.
- To maintain your selected turn radius, the shallowest bank is required when flying upwind.
- The crab into the wind on the downwind loops is applied by turning just a tiny bit faster (i.e., increasing your bank angle) than you normally would if you were flying this arc in a no-wind condition.
- The crab into the wind on the upwind loops is applied by not turning as fast (i.e., decreasing your bank angle) as you normally would if you were flying this arc in a no-wind condition.
- The straight and level portion of this maneuver flown between pylons should be tangent to both patterns.

**Maneuver Notes**

- This maneuver is nothing more than two individual turns around a point that are placed side-by-side.
- Unlike the previous ground reference maneuvers, this one can be done as low as 500 feet AGL. The reason for this is that eights around pylons is the most advanced of all the previous ground reference maneuvers. Therefore, performing this maneuver at a lower altitude requires more skill and diligence on your part compared to performing it at a slightly higher altitude. Things appear to happen faster when you’re operating closer to the ground.
Eights-On-Pylons

Also called pylon eights, this is the maneuver you’ve been waiting for. It’s not required for the private pilot test, but it is a required for commercial pilot and flight instructor applicants. If you’re a private pilot and want to really sharpen your proficiency, this maneuver is for you. You’ll soon be an eights ace. Why? Because the educational objective of this maneuver is primarily to teach, develop and test your ability to fly your airplane subconsciously, while your attention is almost entirely focused on ground references.

Unlike eights around pylons, this maneuver is about being on the pylon, meaning that an imaginary reference parallel to the airplane’s lateral axis (as visualized by you from the cockpit) pivots on (about) the pylon. There’s a big difference between going around something and being on something in regard to these two maneuvers. What’s common between both maneuvers is that they make a somewhat similar eight shape around two ground references (Figure 35). But that’s about the only commonality between them.

The maneuver we previously studied, eights around a pylon, required you to maintain a constant radius around a ground reference, thus providing a circular ground track. The physical objective of Eights on pylons, in contrast, requires that you use whatever bank angle and radius from the pylon that are needed to place the imaginary lateral reference directly on the pylon and keep it there throughout the turning portion of this maneuver (Figure 36).

This maneuver is all about pivoting on a pylon rather than trying to maintain a constant radius of turn about one. Notice that, except for the straight flight portions of this maneuver (positions between I and J, and B and C) the wing always points toward and pivots about the pylon. This pointing is actually done by a lateral reference as seen from the cockpit in Figure 36.
From the cockpit it looks like your lateral axis reference actually pivots about the pylon, thus the reason for the “on” in eights on pylons. After flying around the pylon (when wind is present), your ground track isn’t circular. Instead, it takes on the shape of an ellipse, with the pylon located at one foci (near one side of the ellipse).

Except for the straight portions of this maneuver, you’ll make no attempt to maintain a constant radius of turn or correct for wind using a wind correction angle to manage drift control. If there is any wind present, you’ll find that you actually have to change your altitude to keep this lateral axis reference on the pylon. Unlike other ground reference maneuvers, this one doesn’t require you to maintain altitude or to keep the airspeed constant. In fact, if you’re performing this maneuver correctly when wind is present, your altitude must vary to keep that imaginary lateral axis reference directly on the pylon as you pivot about the reference.

The altitude necessary to make this work is known as the pivotal altitude and this value is solely a function of groundspeed. To obtain a good understanding of pivotal altitude, please read the sidebar, What is This Pivotal Altitude of Which You Speak? on page 7-32. Let’s take a closer look at how to do this maneuver. We’ll discuss the intricate details later.

Begin this maneuver by selecting two ground references (the pylons) on an imaginary line lying 90 degrees to the prevailing winds (Figure 37). These pylons should be chosen to allow approximately three to five seconds of level flight crosswise between them. Using a distance of approximately 600 to 800 feet works fine for this maneuver. If you remember what your height above ground looks like at a pattern altitude of 800 feet AGL, then pylons separated at this distance (or a little less) usually work fine when performing this maneuver at a low cruise airspeed of 100 knots in the clean configuration. I find this speed a reasonable value for beginning this maneuver, too.

What about your initial entry altitude for eights on pylons? Having read the sidebar on pivotal altitude, you know that this altitude is based solely on your groundspeed, which depends on your airspeed and the wind speed. If your groundspeed is approximately 100 knots (you’re just guessing here and that’s OK) as you enter the maneuver, your pivotal altitude is 884 feet. So it’s reasonable to enter this maneuver at an altitude of 900 feet, since your initial turn on the pylon occurs at a location where you have a tailwind (where your groundspeed is the highest), thus requiring the maximum pivotal altitude (Figure 38). As you begin your pylon turn into the wind, the pivotal altitude decreases, meaning that you’ll have to descend to keep the imaginary lateral reference on the pylon.
What is This Pivotal Altitude of Which You Speak?

It’s time to get your bearings, because it’s your turn to learn pivotal altitude. There is an altitude—the pivotal altitude—for any given ground-speed at which an imaginary reference line (one that’s parallel to the airplane’s lateral axis and beginning at the pilot’s eye level) appears to pivot on that point as the airplane turns. This altitude is solely a function of the airplane’s groundspeed. This means that the pivotal altitude changes if the airplane’s groundspeed changes.

Here’s why this happens. Airplane A moves at a groundspeed of 100 knots at a 45 degree bank at 884 feet AGL. Because of its speed it flies around a relatively large arc with a large radius of turn. At 884 feet AGL with a 100 knot groundspeed, airplane A pivots about a point on the ground as seen from the line-of-sight view out of the left or right window.

Airplane B moves at a groundspeed of 80 knots at 45 degrees of bank at 566 feet AGL. Because of its slower groundspeed relative to airplane A, it flies around a smaller arc with a smaller radius of turn. At 566 feet AGL with the same 45 degree angle of bank, airplane B also pivots about the same point on the ground as seen from the line-of-sight view out of the left or right window.

Airplane C moves at a groundspeed of 60 knots at a 45 degree bank at 318 feet AGL. Its slower speed means it moves through an even smaller arc with a small turn radius. At 318 feet AGL with 45 degrees of bank, airplane C appears to pivot about the same spot as airplane A and B.

There are two very important points to take away here. First, anything that reduces an airplane’s groundspeed reduces the circular arc circumference through which the airplane moves. Therefore, the airplane’s pivotal altitude decreases with a reduction in groundspeed, and increases with an increase in groundspeed.

Second, pivotal altitude doesn’t vary with the bank angle to any significant degree, as shown in the figure below. It’s true that your distance from the pylon affects the bank you use during your pylon turn but this doesn’t affect the pivotal altitude. This is seen below with a larger radius of turn needed for a 30 degree bank in place of the 45 degree bank (and shorter radius of turn) used above.

If you’re at pivotal altitude and start this maneuver close to the pylon, then you’ll need to use a larger bank angle when pivoting about the pylon. If you enter this maneuver farther away from the pylon at the appropriate pivotal altitude for your groundspeed, then your bank will be much less. This is a very important distinction to understand. It’s also why, when beginning this maneuver, you’ll want to maneuver far enough from the pylon so that the bank at the steepest part of this maneuver doesn’t exceed 40 degrees. The recommended bank at the steepest part of this maneuver should be between 30 and 40 degrees, so pick a horizontal distance from the pylon (or modify the distance you’re using) that keeps you from exceeding 40 degrees of bank on your initial turn entry.

If you’re interested in how pivotal altitude (PA) is derived mathematically, here’s the formula. As a general rule, PA = \( \text{groundspeed}^2/11.3 \) (knots) or 15 (mph). The important thing to understand here is that the formula for PA makes reference to groundspeed and nothing else. Groundspeed is everything in PA.
Here’s a point that might not seem intuitive to you. The bank you’ll use for this maneuver is entirely dependent on your distance from the pylon. For instance, when you’re flying anywhere on the downwind side of the pylon—as defined by a line running through both pylons and perpendicular to the wind—turning about the pylon moves you in a direction that’s a combination of the airplane’s motion and a wind that blows you away from the pylon (Figure 39, positions A to B). This results in the loop around the pylon stretching outward and forming an ellipse. As you move away from the pylon (from positions A to B) and begin heading into the wind (position B), your ground speed decreases. Therefore, you’ll need a shallower bank at a lower altitude to keep your lateral reference on the pylon.

When flying anywhere on the upwind side of the pylon, the wind combined with the airplane’s motion moves you inward, closer the pylon (Figure 39, positions C to D). This results in a loop that’s closer to the pylon (position D). As you begin to turn downwind (position D) your close proximity to the pylon and the increase in ground speed requires you to steepen the bank to maintain your lateral reference on the pylon.

The bank required when heading directly into the wind (shallow) and when turning downwind (steep) comports with the other ground reference maneuvers we’ve studied. The only thing that’s changing here is the altitude (your pivotal altitude) you must be at to keep your lateral reference on the pylon.

Since you’ll want to use banks between 30 and 40 degrees during the maneuver, it’s best to start this maneuver with sufficient horizontal distance from the pylon so that the pylon appears a little
above the 45 degree diagonal between straight-down and the wing. This applies to both a high and low wing airplanes (Figure 40, position 1). Additionally, as a general rule in a low wing airplane, if the pylon is at or just below your wingtip, then the bank angle at which you begin the maneuver shouldn’t need to be too steep (Figure 40, position 2).

**Let’s Get It “On” the Pylon**

Let’s position ourselves to enter this maneuver so that our first pylon turn will be made into the wind, meaning that the pylon will be off to our left, as shown in Figure 41, position A. Enter the maneuver by flying downwind (or nearly so since you’re flying crosswise in a crabbed condition with the wind as shown in Figure 41, positions B and C.) Once you’re positioned properly, fly a wings-level, straight ground track to that pylon by applying the necessary WCA. Of course, entering this maneuver is important but it’s not as important as your perform-
The lateral reference used to pivot about the pylon isn’t the wing’s lateral axis. Instead, it’s a “line of sight” between your eyes and the pylon that’s parallel to the airplane’s lateral axis. This occurs below the wing in a high wing airplane (position 1) and above the wing in a low wing airplane (position 2).

Once you’re directly abeam the pylon (Figure 41, position D), roll into a turn and place your imaginary lateral reference line (that starts at your eye level and parallels the airplane’s lateral axis) directly on the pylon (Figure 42, positions 1 and 2). Some pilots talk about putting the wing on the pylon, but you’re actually placing this imaginary lateral axis reference on it (Figure 42, positions 3 and 4). This imaginary line is parallel to the airplane’s lateral axis and often appears at different vertical positions when viewed in high and low wing airplanes (Figure 42, positions 1 or 2). If you’re sitting in front or behind in a tandem seated airplane (Figure 42, positions 5 and 6, respectively), then this imaginary reference line will vary based on seating position.

When sitting side-by-side, each seat offers a similar view of where this imaginary reference line is located, assuming both seat occupants have equal seating (eye) heights. The same principle applies in all instances, regardless of where you see this line. Place that lateral reference line directly on the pylon. Your objective now is to keep it there. Here’s how to make that happen.
As the airplane turns upwind (Figure 43, positions E to F and L to M), its groundspeed decreases. That means pivotal altitude also decreases as shown in the *Pivotal Altitude vs. Groundspeed Graph* in Figure 44. To keep the reference line on the pylon you’ll need to apply slight forward elevator pressure to initiate a descent (Figures 45 and 46). If you didn’t decrease your altitude slightly beginning at position E and extending through position F in Figures 43, 45 and 46, the reference line will begin to move behind the pylon (or the pylon moves ahead of the reference line) as shown in Figure 47. As a memory aid, think of moving your elevator control in the direction of the pylon. If the pylon moves ahead of the reference line, you move the elevator forward a bit to descend. At position F in Figure 43, the groundspeed is the slowest and the pivotal altitude is the lowest.

As you continue the pylon turn, the groundspeed increases (Figure 43, positions F to G to H). Any turn away from a direct headwind means your groundspeed increases and increasing groundspeed means an increase in pivotal altitude (Figure 44). If you didn’t bother to increase your altitude slightly, you’d notice the lateral reference line moving ahead of the pylon (the pylon moves behind the line), as shown in Figure 48. To prevent this, begin a slight climb to keep the reference point on the pylon. Once again, move the elevator in the direction of the pylon. Since the pylon is now moving aft, move the elevator control slightly aft to begin a climb that will return you to the pivotal altitude.

What’s happening here is that you’re maintaining the required pivotal altitude by looking at the reference point and climbing or descending slightly to keep the lateral reference line on that pylon. Unlike other ground reference maneuvers, you aren’t concerned about holding altitude, maintaining a specific radius of turn or maintaining a circular ground track. Nor are you concerned about variations in airspeed, because
Chapter 7 - Ground Reference Maneuvers

Pivotal Altitude Changes With Changes in Groundspeed

As the airplane heads into the wind (positions D to F and K to M) the groundspeed decreases. Therefore, the pivotal altitude decreases and the airplane must be pointed nose down slightly. As the airplane turns away from a direct headwind (positions F to H and M to O) groundspeed increases and you must apply slight aft elevator pressure to increase your pivotal altitude.

They will occur with this maneuver. That’s just fine. This is all about keeping that lateral reference line on the pylon.

As you move from positions F to H in Figure 43, you’ll find that you’ve had to climb a little more to remain at pivotal altitude. When reaching position H, you’ll want to roll out, maintain altitude and fly wings-level to position K, where you’ll begin a right pivot around the pylon. This means that you must roll out on a heading that allows you to fly for three to five seconds diagonally between pylons and arrive at approximately the same distance from the pylon that you used when beginning your first pylon turn. So you must roll out crabbed into the wind with a wind correction angle applied to correct for drift (Figure 43, positions I and J). Make your best estimate for the WCA and modify it, if necessary, to maintain the selected ground track.

When reaching Figure 43, position K abeam the second pylon, it’s time to lower the wing and place the lateral reference line directly on the pylon. Now apply the same techniques used to maintain your pivotal altitude through positions K and O in Figure 43.

Plan on doing two full circuits of eights on pylons to demonstrate that you have sufficient skill and don’t hate the eight. With a little practice, you’ll become proficient at this maneuver. When you do it says something very positive about your airmanship skills.
Here are a few tips and tricks about eights on pylons.

Sometimes pilots use the term *wingtip* to refer to the lateral reference line, but you’re not actually using the wingtip for this maneuver.

You want to choose pylons that are easy to see from the pivotal altitude. Having to hunt for your pylon adds unnecessary difficulty to an already challenging maneuver. Road intersections make ideal pylons. Isolated trees are very good, too. I don’t recommend using livestock, since it’s best that pylons not move, nor should they yield anything that requires USDA grading. It’s also wise to pick pylons both of which are at the same altitude. If one’s on a hill and the other in a valley, you add another level of difficulty to this maneuver.

Sometimes turbulence or inattention can cause your heading to change and displace the lateral reference line from the pylon. In other words, one minute your lateral reference is on the pylon and the next minute it’s pointed somewhere else entirely. The best way to handle this is to shallow out or increase the bank as appropriate to get that lateral reference line back on the pylon. What you don’t want to do here is to use rudder to yaw that reference line into place. This is one of the most common errors among pilots lacking good stick and rudder skills. For them, it’s just too easy to slip or skid the airplane to place the lateral reference line on the pylon. Keep in mind that skidding the airplane with rudder is a risky thing to do at such a low altitude. Think spins here.

Now that you’re grounded on the essentials of maneuvering with reference to the ground, let’s put the airplane on the ground by flying an airport’s traffic pattern.

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**The Essentials of Eights on Pylons**

The physical objective is to use whatever bank angle and radius from the pylon are needed to place the imaginary lateral reference directly on the pylon and keep it there throughout the turning portion of this maneuver.

**Why Do We Do It?—**

The educational objective of this maneuver is primarily to teach, develop and test your ability to fly your airplane subconsciously, while your attention is almost entirely focused on ground references.

**Ground Reference Needed—** Select two ground references (the pylons) on an imaginary line lying 90 degrees to the prevailing winds and about 600 to 800 feet apart. These pylons should be chosen to allow approximately three to five seconds of level flight crosswise between them.

**Eights on Pylons, Step-by-Step—**

- Begin this maneuver at a low cruise airspeed of 90 to 100 knots in the clean configuration.
- Enter the maneuver by flying downwind (or nearly so since you’re flying crosswise with the wind).
- If your groundspeed is approximately 100 knots (you’re just guessing here and that’s OK) then use an approximate initial pivotal altitude of 900 feet to begin this maneuver.
- Once you’re directly abeam the pylon, roll into a turn and place your imaginary lateral reference line directly on the pylon. Your objective now is to keep it there.
- Since your groundspeed is the highest when entering this maneuver, you’ll find that you need a steeper bank to keep your lateral reference on the pylon.
  - As the airplane turns upwind its groundspeed decreases and you’ll need to apply slight forward elevator pressure to initiate a descent to a lower pivotal altitude.
  - As the airplane turns with the wind its groundspeed increases and pivotal altitude increases. You’ll have to climb to remain at pivotal altitude.
  - You’ll roll out and fly wings level between pylons (you must anticipate the WCA to reach the next pylon at the desired offset distance) to a point where you’ll begin a pivot in the opposite direction of turn.
  - When reaching a position abeam the second pylon, lower the wing, place the lateral reference line directly on the pylon, and apply the same techniques discussed previously to maintain your pivotal altitude.

**Maneuver Notes—**

- Throughout this maneuver you’ll make no attempt to maintain a constant radius of turn or correct for wind using a wind correction angle to manage drift control (except on the straight and level portions between pylons).
- If there is any wind present, you’ll find that you actually have to change your altitude to keep this lateral axis reference on the pylon.
- Unlike other ground reference maneuvers, this one doesn’t require you to maintain altitude or to keep the airspeed constant.
- If you’re performing this maneuver incorrectly when wind is present, your altitude must vary to keep that imaginary lateral axis reference directly on the pylon as you pivot about the reference.
- Pivotal altitude is solely a function of groundspeed, meaning that pivotal altitude changes if the airplane’s groundspeed changes.
- Pivotal altitude doesn’t vary with the bank angle to any significant degree.
- You’ll want to use banks between 30 and 40 degrees during the maneuver.
- It’s best to start this maneuver with the pylon a little above the 45 degree diagonal between your seat and the wing on a high wing airplane.
  - In a low wing airplane, start with the pylon just below your wingtip.
  - If you’re sitting in front or behind in a tandem seated airplane, then this imaginary reference line will vary based on seating position.
- The imaginary line is parallel to the airplane’s lateral axis.
- Memory aid: move your elevator control in the direction of the pylon.
- You’re maintaining the required pivotal altitude by looking at the ground reference point and climbing or descending slightly to keep the lateral reference line on that pylon.