NAILING THE APEX

Every corner has a mid-point—but it may not be in the middle

We knew it was time to launch this magazine when we saw the car commercial that has the young boy playing with his food. The kid is pretending to drive, pushing his fork through his mashed potatoes, carving corners through an imaginary road. The kid's father admires the fantasy driving but then sternly admonishes, "Now son, remember: Always accelerate from the apex!"

Well, dad is right. The apex concept is integral to the entire body of performance-driving knowledge. As you're carving through a corner, the apex is the innermost point of your driving line through the arc of the turn. It's the point that separates your corner entry from corner exit, and it's necessary to hit this mark if you're to drive the fastest line.

Now, don't assume that your apex is necessarily located in the middle of a corner. Depending on the type of corner you're driving through (as well as the corner you're heading to next), your apex might need to be located before or after the corner's geometric mid-point. Here's a rule of thumb you should commit to memory: The proper apex is the one that allows the earliest throttle application while unwinding the steering wheel, all without requiring any steering correction as the car proceeds down track.

Let's break down this maxim. Besides having fun and learning more about car control and safety, an objective of high-performance driving is to drive fast—to complete a lap in as short a time as possible. In this quest for lower lap times, a primary goal is to spend as little time as possible in the longest, most time-consuming sections of the track, the straights. To do this, you must increase your speed in each straight, with a focus on achieving the highest possible top speed before the moment when you need to brake for the next corner. And it's this goal that requires that you exit your corners with as much throttle as possible. (See diagram at right for a full explanation.)

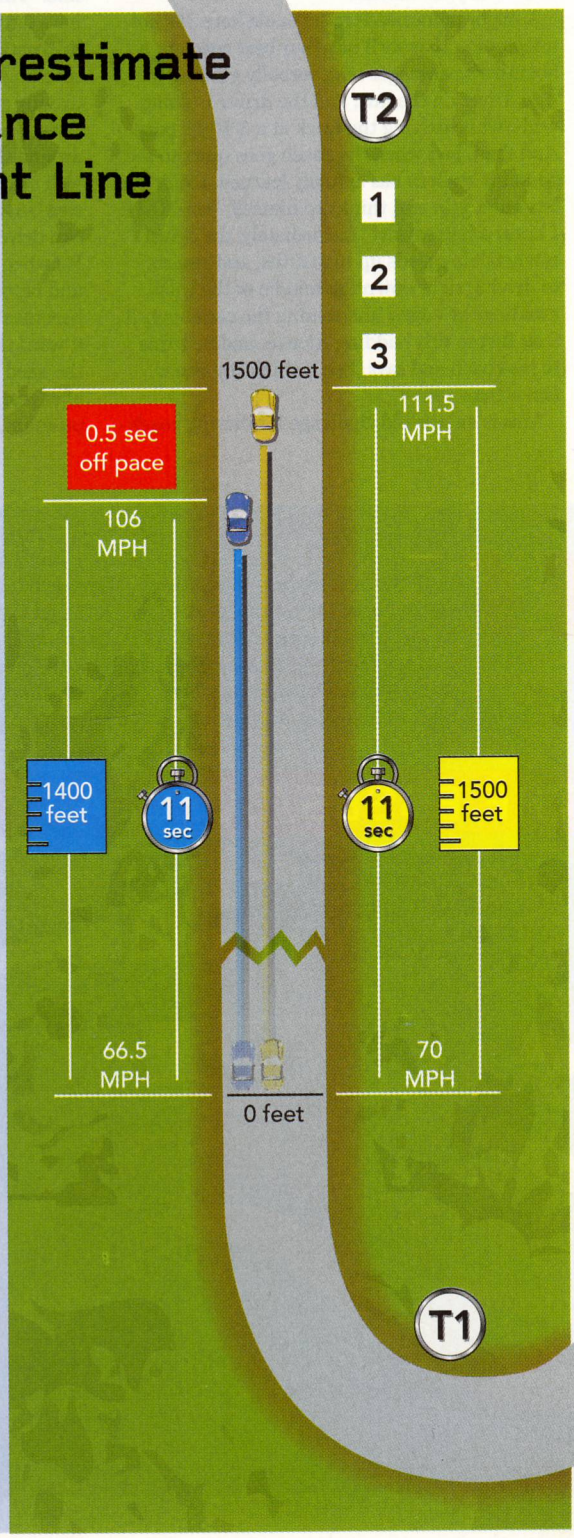
By virtue of when and where you can safely apply throttle in a corner exit, your ideal apex point will vary from turn to turn. But by taking a quick survey of all the road courses we have in America, we're going to state that the majority of the turns you encounter will call for a late apex. In simple terms, the late apex compromises the beginning part of the turn—making it tighter—so that you can straighten out the later part of the turn in order to achieve maximum accel-

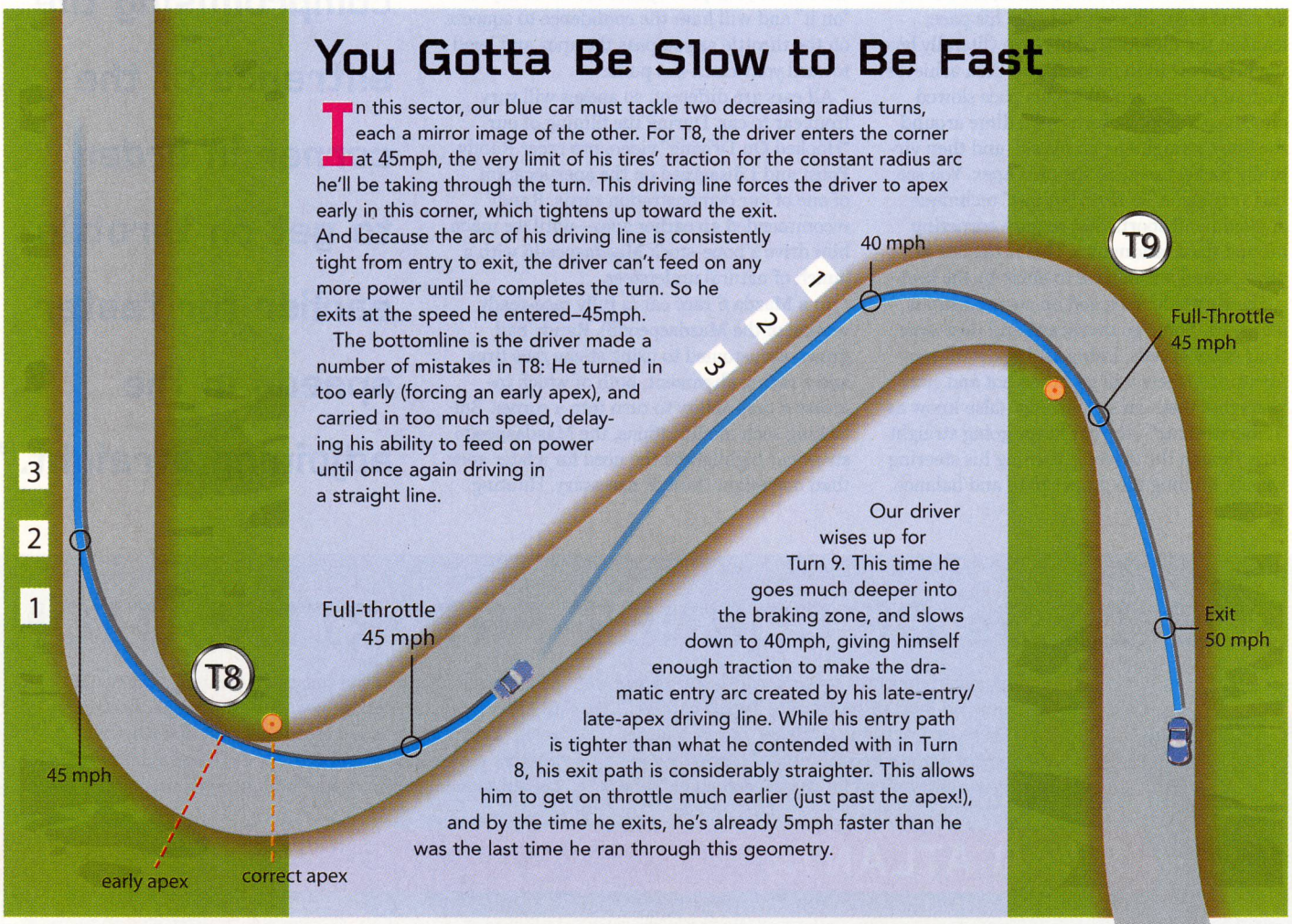
Never Underestimate the Importance of a Straight Line

Straightaways not only consume the lion's share of most tracks' real estate, they also afford the best, most productive opportunities for full-throttle acceleration. Because of this, the speed at which you begin your drag race down a straight becomes vitally important. This means you must exit preceding corners with as much momentum as possible. We explain the principles behind fast corner exits in the next diagram, but for now, let's use a 1,500 feet straightaway segment to demonstrate just how critical full-throttle speeds really are to overall lap times.

Our blue and yellow cars have exited Turn 1 side-by-side, but the yellow car's exit speed is 3.5mph faster at the zero foot mark. This seemingly minute speed difference is actually quite profound. In just 11 seconds, the yellow car reaches the braking zone for Turn 2, with a top speed of 111.5mph. In that same 11-second time period, however, our blue car is still 100 feet short of the braking zone. It will take the blue car 11.5 seconds to complete the straightaway–putting it a half-second off pace in just a single section of a single lap.

So how did our yellow car achieve the faster corner exit speeds? He probably followed the principles of "slow in, fast out," which our blue car doesn't learn until Turn 9 on the following page...





eration as you exit. Late apexes are particularly appropriate for tight turns, whereas softer turns are better suited to a middle apex, and in some rare cases, even an early apex.

Be very aware that if you drive an early apex on a tight corner, the geometry of your driving line will have you pointing off the pavement by the time you exit the turn. This isn't a disaster if your tires have some extra grip available, as you can wind in more steering lock, and keep the car on the road. But if you're driving right to your tires' limits of adhesion, your car won't be able to turn any more, and that early apex will have you running into the weeds—or worse. It's for this reason that we advise beginners to take a decisively late apex in many corners. The late apex simply allows for a greater margin of error in most cases.

Many event organizers will place orange cones around the track to mark entrance, apex and exit points. But if these cones are missing, and you're having trouble identifying an apex, study your track map and imagine that you have to start a drag race as you exit each turn. With a pencil, mark the spot that would allow you to best launch the car toward the next turn, all without having to fight the car to do it. This should give you a good bead on where and how to position your car for that launch.

In the majority of corners you'll encounter on a road course, apexing past the mid-point of a turn will give you a driving line that has your car pointing in the right direction and eager for acceleration. This gives you the confidence to get on the throttle sooner, which yields a quicker top speed before the next braking zone.

At our events we have plenty of beginning drivers who fight us on the wisdom of late apexing. Their desire to be quick fuels a general attitude of impatience, and it's this impatience that has them turning in too quickly, leading to early apexes. "After all," they're thinking, "fast is fast, right? So I should turn in as fast and as early as possible, right?"

Wrong.

This is where the famous coaching maxim "in slow, out fast" comes into play (see diagram on this page). To accomplish your late-apex exit on throttle, you must give up just a bit of speed on entry—all without giving up momentum—so that your car is under control as you make your turn-in and apply progressively more throttle on exit. Remember: You're compromising the entrance of the corner in order to get on throttle earlier for faster speeds in the adjoining straight.

Think of the champion slalom water skier slicing the water from buoy to buoy, side to

side. The speed and cornering that these guys and gals achieve is amazing—they literally fly across the boat wake from one side to the other. But note how, as a skier enters a turn, he turns a ski sideways to brake his pace, leans in the direction of his turn (literally laying his elbow in the water), and then achieves that magic moment: With his pace slowed almost to a stop, he turns on a dime around the buoy, straightens up his ski, and then virtually rockets away to the next apex. You see this very same "in slow, out fast" technique applied in all sports that require cornering around fixed landmarks. This is the law of physics, and we all have to abide by the law!

The surrender of speed on corner entry is a fine art. Some go overboard and over-slow their entry speeds, losing all-important momentum. Others will go in too hot and complain that their car is "pushing" (also know as "understeering"—the car keeps going straight even though the driver is turning his steering wheel). Finding the proper pace and balance upon corner entry is the key—and you'll know it when you find it. The car will rotate with no complaints from your front tires, and in the seat of your pants you'll realize that you're "on it" and will have the confidence to squeeze on the throttle as you pass the apex and head toward your track-out point.

All cars are different, so apexes will vary from car to car. During the filming of our "Hooked On Driving" video, pro racer Randy Pobst and I disagreed on the apex location of one of our demonstration turns. Randy recommended an earlier apex—until we made him drive a bone-stock Mazdaspeed6 with a bunch of natural understeer.

In a Mazda 6 race car (a fully race-ready version of the Mazdaspeed6), Randy had grown accustomed to using sticky race tires and a racing alignment, both of which increase a car's ability to turn into a corner. But lacking such modifications, the Mazdaspeed6 street car highlighted the need for a later apex than one might think is necessary. Hunting

"You're compromising the entrance of the corner in order to get on throttle earlier for faster speeds in the adjoining straight."

THE 1,2,3s OF CORNER PRIORITIZATION

The most important corners, which you should work on most diligently, are **Type 1** corners. These lead onto the straights (or any long sectors of flat-out acceleration). Make sure you maximize your entry speed for these. Next come **Type 2** corners, which are at the end of the straights (you want to maximize the length of your full-throttle acceleration zone). **Type 3** corners are those that lead directly onto another corner, and might need to be "compromised" if the subsequent corner deserves higher-priority.

ROAD ATLANTA

for the best point to touch the inside of the turn, we found that if we wanted to exit the turn with as much throttle as possible, Randy's middle apex would be just too early. A middle apex would induce understeer, forcing us to either (a) plow ahead into run-off area, or (b) lift off the gas in order to "rotate" the car, keeping it on line. (There's more about this advanced technique on page 35.)

OK, now here's where we throw you some curve balls. First, the 90-degree turn: The late apex fits the bill for most corners, but our long-time affection for street circuits (think about those races on the boulevard grids of Long Beach, Houston, and San Jose) has influenced road course designers to include a variety of right angles in their track layouts. In the "90," a late apex would have you giving up too much speed. A more delicate approach—mid-apexing—is the quickest way through this right-angle turn. You'll actually learn to love these turns, as they're quicker than they look in many cases.

Some more curve balls: Every road course has its own unique character, and will demand adjustments to standard practice. Three examples come to mind.

» Elevation change. If the track is turning and changing elevation at the same time, you may need to deviate from the basic principals of apexing. Always keep in mind that you need to finish all your steering input before you crest a hill. Because your car will get very light at the crest, any steering input will encourage a sideways slide as the car loses grip on top.

» Pavement camber. A negative-camber (or "off-camber" corner), where the roadway slopes downward from the curvature of the turn, will reduce your car's cornering grip. The line for these turns may be best taken closer to the center or inside edge, rather than the traditional outside edge. This line will help defeat the effect of your car having to drive across a downward slope as it circulates the turn. Conversely, if a corner is banked—like the sweeping corners of an oval NASCAR circuit—your car will have more grip, and a more aggressive line might provide the fastest way through.

» Throwaway turns: Sometimes, a course is so twisty and snaky that a small turn between two bigger turns will require that you surrender the optimum line in the middle turn so that you can nail the apex on the final turn, and feed on maximum-possible acceleration as you exit. That final turn typically leads to a long straight (or at least a section that allows for wide-open throttle), so it's imperative that you compromise the apex of the throwaway corner preceding the "Type 1" corner (see diagram at left).

BRAKING & ACCELERATING

Stringing together rapid movements with utmost smoothness

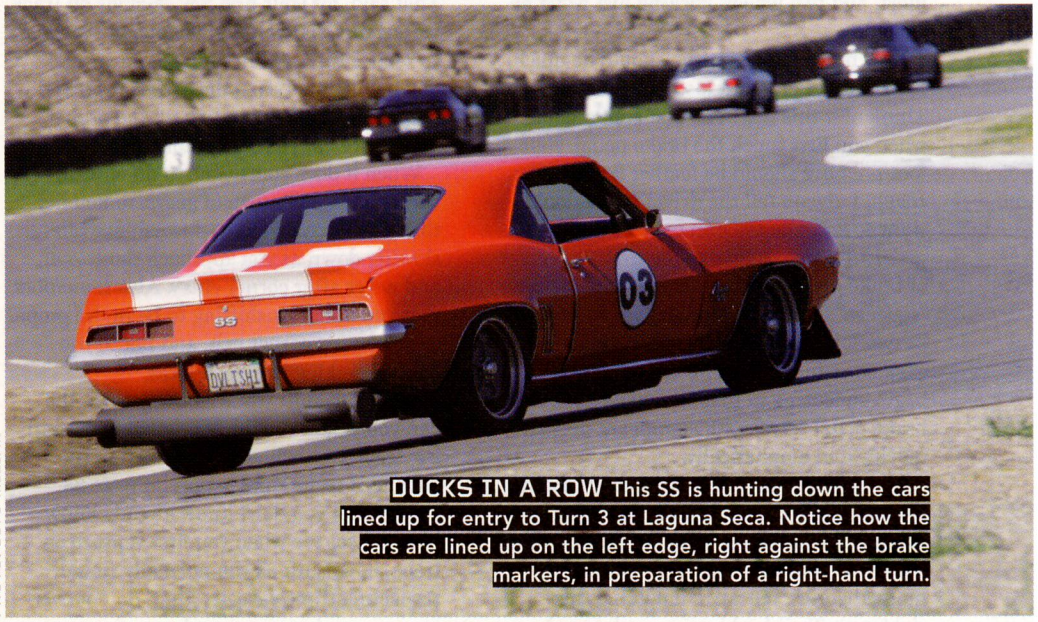


PHOTO: DITO MILIAN

DUCKS IN A ROW This SS is hunting down the cars lined up for entry to Turn 3 at Laguna Seca. Notice how the cars are lined up on the left edge, right against the brake markers, in preparation of a right-hand turn.

OK, so you've learned the line, and you can now drive lap after lap hitting all the proper entrance, apex and exit points. It might have taken a full track day to get to this far, but you've finally found that elusive rhythm through the course. It's now time to pick up the pace, and begin making actual speed through the corners. It's also time to consider an irony about high-performance driving: As beginners really begin cooking through the turns, they discover that it's slowing down, and not speeding up, that presents the more difficult challenge.

Indeed, proper braking—slowing down *right now*, all without upsetting the car—segues from "optional" to "essential" as we begin approaching our cars' true limits. We not only develop a whole new respect for braking, we discover the need to use the brakes with delicacy, not bravery.

Over years of coaching, our instructors have noticed the same common mistakes made by beginners. It goes something like this: As the driver approaches a turn at speeds faster than he's accustomed to, all hell brakes loose with his footwork and shifting. He abruptly lifts off the throttle, coasts into the braking zone, and then hits the brakes hard, turning in randomly (and usually too soon) with the occasional bonus of a frantic downshift in the middle of the turn. While modern performance cars are capable of near miracles, this cornering approach will only support us at a 4/10ths pace. As such, we all have to learn techniques that provide a smoother transition from going fast to going slow, and turning into a corner.

Making your way through corners quickly and smoothly—all while maintaining adhesion on all four tires, and without upsetting the car's balance—is essential to a quick and consistent pace on track. Unfortunately, however, it's not automatic if you've spent your entire life driving on city streets. So let's break down the four-step process that will lead to quick, graceful performance laps.

Braking

First you need to pick a braking point. Choose a distance from your turn-in point that's not only safe, but also within your personal comfort zone. If the braking zone is marked by brake markers (e.g., numbered signs on the side of the pavement: 3, 2, 1), you can start your braking at the first marker, if not earlier. Make sure to carry speed all the way until you're ready to slow the car—no cheating by gradually lifting off the gas and coasting into the braking zone. It's a bad habit that you won't want to unlearn as a more advanced driver.

At your appointed spot, with your car positioned for entrance to the turn (remember: "outside, inside, outside"), gently take your right foot off the gas, and move it decisively to the brake pedal—*but don't stomp on it.* You might be able to get away with a foot stomp while going slow, but if you stomp at a pace closer to the edge, you will move the

weight of the car too abruptly to the nose, leaving the rear tires with insufficient grip. In this state, the car becomes unstable upon corner entry. This is when you need stick the most, and two wheels sticking just won't be enough.

Your braking application should be quick, firm and decisive, but also progressive. Think of it this way: For that split second when you first touch the brake pedal, your foot pressure should be feather light. (As a coach, I always tell the driver that I don't want to actually *feel* him or her touch the pedal.) Then, for perhaps the first 10 percent of brake pedal travel, your foot should gently "squeeze" the pedal. This motion should be quick but also delicate. Now, with the car's nose duly settled for turn-in, you can begin squeezing in that last 90 percent of brake pedal travel with significant pressure, quickly and emphatically.

All of the braking described above should be done while the car is traveling in a straight line. Braking while turning in, also known as trail-braking, is supported by many theories, but we're not going there right now. Trail-braking is an advanced technique, and any discussion on how and when to use this skill will inevitably entail a dizzying mix of empirical data and subjective opinions. If your friends are pushing you to trail brake, push back—at least until you have the car-control skills to catch the spins that sloppy trail-braking can provoke (see page 32 for details).

Downshifting & Turning

The rule of thumb on gear choice is that you always want to be in the gear that will give you the quickest acceleration out of corners. That said, for your first few sessions on track, we suggest that you use just one or two gears to reduce the amount of time you spend down-shifting. Learn the course first, and then start shifting through all the proper gears once you're comfortable.

When it does come time to downshift through the full range of gears, remember that you always want to downshift while slowing down as you approach the corner, and never after corner entry. Also remember that you are downshifting to be in the proper gear for your corner exit, and not to use engine-braking to slow the car.

Ideally, to shift while slowing down the car, you would use the "heel-toe" downshifting technique, which is described in the advanced techniques article on page 28. However, if you don't know already know how to heel-toe when you first venture on track, downshift as you normally would, respecting three caveats: First, do not over-rev your engine as you grab your lower gear. Second, as you disengage the clutch pedal, feather it off gently to reduce the possibility of "chirping" your tires, which upsets the car and stresses the drivetrain (many a rear end has been damaged by aggressive down-shifting). Third, always get your downshift completed before you enter the turn.

Once you have your car slowed down, under control, and still full of momentum, it's time to turn as planned. How you turn the wheel is very similar to our description of how you use the brake—it's all about smooth, progressive motion. You want to feed steering input into the car. You're not a stunt driver, and throwing the car into the turn like a ragdoll is not only foolhardy, but also a sure way to hurt your lap times.

Throwing the car might *feel* faster, as you'll immediately find your grip limits and may even find yourself sideways. But trust us, sideways isn't fast, it's just sideways. So during your turn-in, smoothly feed in all the steering that's required to give your car a "set" toward the apex. The idea here is that you don't want to add any more steering input after you've made this initial set. Turning in too little, then realizing you need to turn a bit more, is never a good thing, as it breaks your rhythm, reduces your car's momentum, and might even hoodwink you into lifting off the gas. (And, as we all know, when beginners spin into the dirt, it's usually because they lifted off the gas in the middle of a corner.) As the car turns, you'll start adding in what we call "maintenance throttle"—gently feed in some gas to maintain the car's momentum from braking to turn-in.

Accelerating

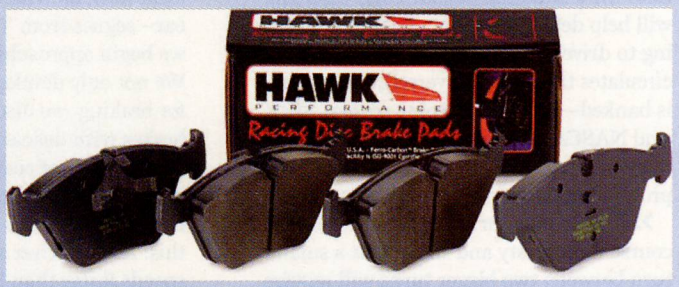
As your apex and track-out points come into view, begin feeding in more throttle, progressively building speed. As we discussed before, fast exit speeds are the keys to fast

HOW MUCH (AND HOW LITTLE) TO BRAKE?

We give you a three-step drills for finding the proper corner entry speed

As we all know, a corner can only be taken just so quickly before our tires lose traction. It doesn't matter if the corner is slow and tight, or fast and sweeping—there's a speed past which a car can't stick. But how exactly do we know when we're entering a corner with just the right amount of speed—slow enough to make it through, but not a skinch slower than we need to be? Here's a useful drill for "working up a corner." Try it out after you've mastered the driving line and have a good number of track days under your belt. *–Jon Phillips*

1) First, begin braking at a comfortable braking point (say, the 3 marker), and at a speed that's low enough to drive the perfect line without any fanfare from squirrelly tires. Make mental notes of exactly where you started braking, and exactly how your car felt as it went through the turn. Drive through the corner this way a number of times so that your sensation of speed through the line feels perfectly familiar. This is your baseline.



These are brake pads. You'll need these to slow down.

2) While keeping the exact same braking point, begin applying less braking pressure in the brake zone. This will result in faster corner entry speeds. In small increments, apply less and less brake pedal pressure, and observe what's happening to your car. As you ratchet up your corner entry speeds, your tires will begin screeching as you apply throttle from apex to exit. A few ticks faster, and your tires will begin screeching even earlier—maybe as soon as you turn in. Now, these are just audio

KISS THE APEX Notice how this blue, mid-engine dynamo uses all of the FIA curbing at his disposal. You paid for all of the track. So use it all.

cues, and you can't rely on them as your only source of feedback. The best way to determine if you've reached your car's entry speed potential is to qualify what it's doing throughout the corner. If your car begins to drift off line, or if you find you can't get on the throttle shortly after apexing, then you've exceeded the car's effective cornering limits. When you reach this point, dial in a bit more brake pressure before turning in. This is your optimal corner-entry speed—your new baseline.

3) The next step (assuming you're ready for it!) is to *shorten* your braking zone so that you can maximize your top speed down the preceding straight. Begin moving your braking point forward in small increments (maybe three feet at a time) while simultaneously increasing brake pedal pressure. Later braking, more pedal pressure. Later breaking, more pedal pressure—*all while making sure your corner entry speed is the same baseline you established at the end of step 2.* If you were pursuing a racing career, you might continue this nibbling-away process until your brake pressure is just short of tire lock-up or ABS engagement, and your brake zone is shortened to a complementary degree.

The drill we describe above is perfect for drivers who don't feel comfortable experimenting with threshold braking from the get-go. Indeed, keeping a car on the precipice of lock-up requires a lot of talent, and when you're braking with this much gusto, you also increase the likelihood of over-slowing the car. That said, once you reach a certain skill level, you can change the drill a bit to speed up the whittling away process. To wit:

A) Brake at the 3 marker, but experiment with braking harder and harder until you can pinpoint just how much brake pressure it takes to lock up the tires. Become very familiar with this pedal pressure, because you'll need to repeat it again and again.

B) After you've identified what it takes to lock up the front tires, begin braking later and later in small increments. Nibble away at that brake zone yard by yard if necessary. By maintaining the constants of threshold braking and a fixed turn-in point, your corner entry speeds will get faster and faster as you dive deeper and deeper into the braking zone.

C) You know you're braking too deep when your entry speeds begin yielding counter-productive results: You begin to understeer through the corner, you have to make corrective inputs to keep the car on line, and you can't get on throttle early enough. So brake a little earlier next time. Voila. You've found the ideal braking point and corner entry speed.

lap times, and the whole point of "in slow, fast out" is to get on full-throttle as soon as possible. That said, your throttle application still has to be gentle and progressive. As you clip the apex, its time to feed on the gas. No stomping, only squeezing, just like you squeezed the brake.

Sounds like we're advocating wimpiness, doesn't it? Far from it. Making a car dance on the knife's edge of adhesion requires a delicate touch. As you progress to a faster pace, you'll realize (especially with high-torque cars) that a stomp on the gas will once again threaten to unsettle the car. But if you *squeeze* the gas you'll be fine. As you feed on the gas, unwind your steering input, and accelerate to your track-out point. When done correctly, you'll feel your rate of acceleration increase almost on its own as you relieve the steering input that's holding the car back.

Now, if you do in fact overdo the gas pedal, you may feel oversteer, with the rear of the car threatening to slide away from your apex direction—in lay terms, you're getting squirrelly, and heading toward spin city. If this happens, (a) you've probably applied too much throttle, taxing the rear tires for more than they're capable of, and (b) you'll need to react quickly to correct the situation. Do *not* lift off the throttle. To repeat the theme: *Lifting in the middle of a turn only increases the likelihood of a spin.*

Nope, what you want to do is quickly—but smoothly—turn into the direction of the slide (that is, "countersteer"), and feather the throttle just a bit to get the car to settle. You may have to give up all dreams of hitting your apex point, but this countersteering correction will at least keep you from spinning.

Putting It All Together

So there you have it: This "cornering thing" can seem like pretty obvious stuff. Nonetheless, we find that new performance drivers frequently struggle with the quick-but-smooth transitions required for braking, turning, and getting back on throttle. The good news is that everyone can practice smooth transitions on public roads. For example, you can practice smooth braking—at legal speeds—as you approach a turn at, say 45mph, going from third gear to second gear, looking both ways, and smoothly turning into a 30mph zone. It's a matter of concentration and working with more precision than you're accustomed to (plus making sure no traffic is behind you when you squeeze on those brakes!). You can also practice heel-toe downshifting as you approach any stop sign or stoplight. After years of track driving and racing, I find myself heel-toe downshifting on virtually every shift without even being aware of it.

Regardless of your skill level, you can always use street driving to refine the precision of your turns. Yes, these drills will be easier to do in a meaningful way in a controlled track environment, but doing homework in this area will prevent you from being shocked by the requirements of high-performance braking once you do reach the track for the very first time. You'll also find yourself becoming a better driver as you begin to concentrate at a higher level, and get to know your car better. For more about safe practice on the street, see page 66.

BIG BOY GO BOOM Take one part big muscle, and add two parts excessive throttle. Blamo! You just made yourself a little concoction we like to call "power-on oversteer."

PHOTO: DITO MILIAN

ESSES FOREVER The Turn 8/9 sequence at Sears Point (aka Infineon Raceway) absolutely demands as much forward vision as possible.

SEEING THE BIG PICTURE

And if all else fails, just remember to practice the following

BY JON PHILLIPS

SMOOTHNESS

If we were to tally the number of times we advocated smooth pedal and steering inputs in this magazine, we might actually run out of integers to work with. So why not repeat one more time? Your inputs should be gentle, progressive, and decisive. If you're just not getting the concept, try this out: At an appropriate speed and without any traffic around, ask your instructor to turn the wheel for you, his hands on top of yours. This often creates a breakthrough, "aha!" moment wherein the student suddenly becomes familiar with exactly what smoothness feels like.

VISION

You must broaden your field of vision in order to drive fast. For example, if you're approaching the brake zone for Turn 3, don't target-fixate at the turn-in cone. Instead, look *past* the apex cone, and toward the exit cone and beyond. And once you've actually started your turn in, you should already be looking up track to Turn 4. Think about it: Once you turn in, you're already committed to the corner. Assuming you're driving on line, your arc will put you on the apex and exit points by necessity, so there's no reason to concern yourself with Turn 3 anymore. It's done. So look to Turn 4, and absorb that big mental picture of where you're driving next. Looking ahead has an almost miraculous effect on smoothness and speed. 75mph begins to feel like 50mph, our sense of urgency goes down, and our rapid-fire decision-making begins to play out in slow-motion, giving us more time to do everything better: smoother downshifts, crisper turn-in, and so on.

ATTITUDE

Think you're a talented driver on city streets? Abandon that thought immediately, because road courses are not city streets. City streets are designed to keep grandmas from rolling their Studebakers. Road courses are designed to vex drivers with technical challenges, and thrill the bejeezes out of them with pucker moments. Even "slow" corners are surprisingly fast. You just can't recognize the speed because all your familiar landmarks (stop signs, parked cars, etc) are missing, and this plays tricks with perspective. So be humble. Accept the fact that performance driving is nothing like street driving, and you have a lot to learn. Don't compare yourself to other students; keep your head in your game, and work on making every lap, session, and track day just a little bit better than the last.