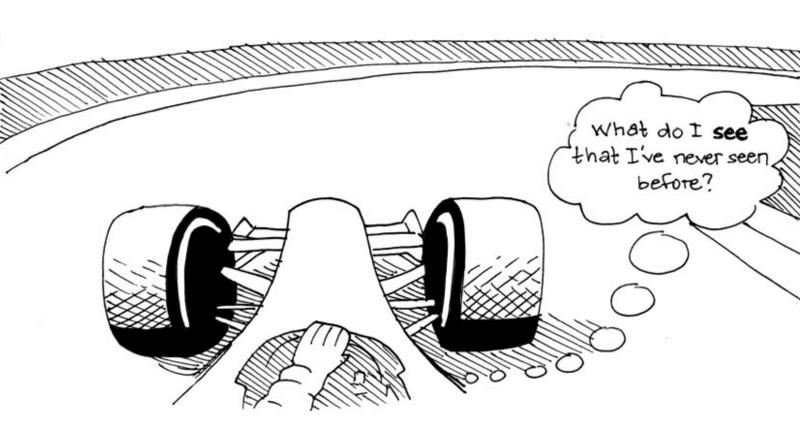
SPEED SECRETS

PERFORMANCE DRIVING ILLUSTRATED

by Ross Bentley



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IMPORTANT STUFF

You know that motorsport of any kind is dangerous. Therefore, I provide my advice for you to use in the way you choose. I can't be held responsible for anything that might happen as a result. You're a grown-up - you're responsible for yourself – and by reading on, you are accepting that responsibility.

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Having said that, I love helping you perform better – I enjoy sharing what I've been fortunate to learn through experience, study, and observation. With that in mind, please help me get this eBook in the hands of more drivers. Please recommend to other drivers that they download their own copy. It's free! All people need to do is download it themselves (i.e., don't send them your copy). Thank you.

Ross Bentley

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Version 1.0, 2-15-16

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INTRODUCTION

Over the years, I've used many illustrations to get my point across when teaching performance driving. These illustrations have mostly been on the white boards I've used in classrooms, but I've also created them for my Speed Secrets books. Recently, I've taken to using my iPad to quickly sketch them out for a driver I'm coaching. And many times I've wished that I'd saved these quick sketches because, for many drivers, a picture is worth a thousand words.

This eBook is a collection of these illustrations. Some stand on their own and don't require much explanation. Other illustrations need a little more context, so I've written some words to accompany them (but less than a thousand per picture!). If you want more detailed explanation of an illustration, well, you're going to need to check out my Ultimate Speed Secrets book.

By no means is this an absolute complete compilation of every bit of information that you need to drive quickly, consistently, and safely around race tracks. If you want more, you'll need to go elsewhere (obviously, I recommend my Ultimate Speed Secrets book, my Speed Secrets Weekly e-newsletter, and especially my eCourses). What is included here are the illustrations and information that I've found myself going back to over and over again through the years. There must be a reason for that – it's because this is the most important stuff.

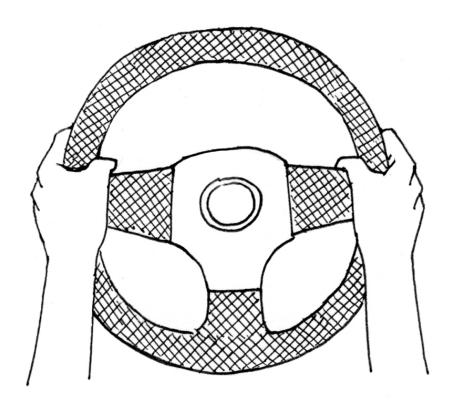
My hope is that these illustrations will trigger thought and provide some extra clarity around a driving technique or concept. Ultimately, they're meant to provide you with more understanding, and be a refresher or reminder of key concepts and information.

Enjoy, and have fun!



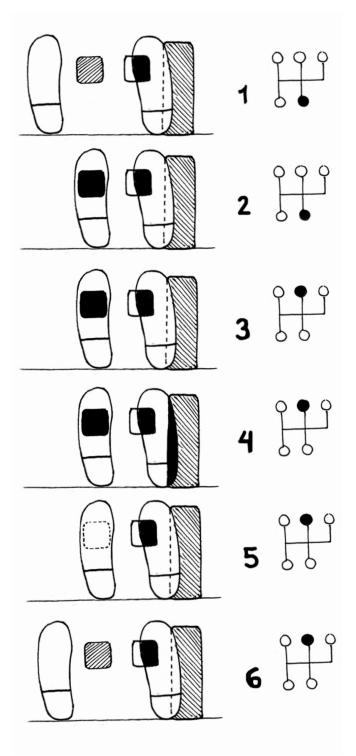
Steering Wheel

Hold the steering wheel at 9 & 3 o'clock. Simple as that. You should be able to drive almost all corners on all tracks without moving your hands from this position. The less you turn the steering wheel, the smoother and faster you'll be. The less you move your hands on the steering wheel, the smoother you'll be. Therefore, the less you move your hands, the faster you'll be able to drive.





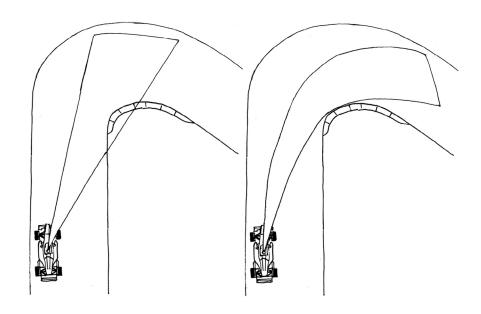
Here, I illustrate the steps, the process, of heel & toe downshifting. This technique's purpose is to allow you to brake fully, while "blipping" the throttle (your right foot operating both the brake and gas pedals simultaneously), so your downshifts are smooth (not upsetting the balance of the car). You'll never be as good as you can be until you master heel & toe downshifting. And even if you drive a car with a semi-automatic or automatic transmission, you should still understand the why and how behind heel & toe.



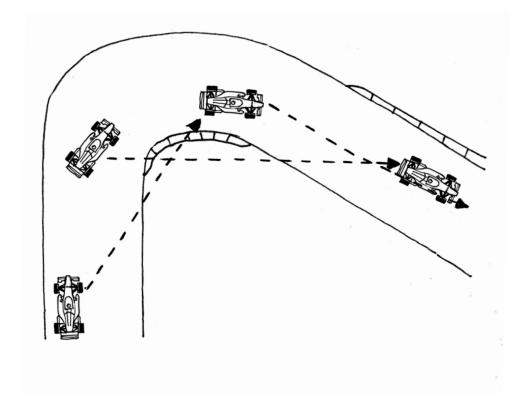


Vision

Look ahead, as far as you can. Look where you want to go, and not where you don't want to go. Turn your head and look around corners. Finally, think through corners as you look through them.



Here's another way of looking at what to do with your vision: constantly scan and look further ahead. This is a smooth process, not one done in steps.





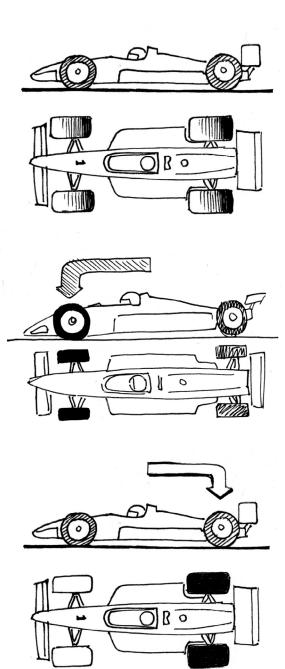
Weight Transfer & Traction

Assuming that a car has equal weight distribution front to rear, each tire has about the same amount of traction when it's moving a constant speed. The car is balanced.

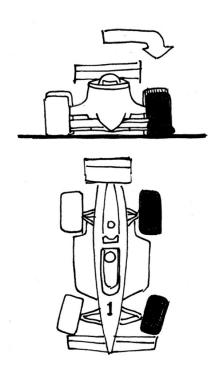
When a tire has more load or weight placed on it, it gains traction. Imagine pushing down on a rubber eraser and pushing it along a piece of paper for an example of how this works. Conversely, when a tire becomes less loaded, its traction is reduced.

When you brake, weight transfers forward, putting more load on the front tires, and giving them more traction than the rears (which have reduced traction because they've had load taken off them).

When you accelerate, weight transfers to the rear tires, and they now have more traction than the front tires do.







1750 1500 TRACTION, Ibs. force 1250 1000 750 Linear 500 Actual Tire 250 Characteristic 0 8 12 10 VERTICAL LOAD, Ibs. X100

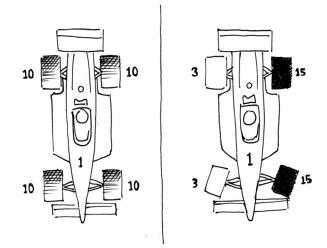
Weight transfer also occurs when going around corners. Weight transfers to the tires on the outside of the turn, causing them to have more traction than the inside tires. As the outside tires have more load put on them, they gain traction; as the inside tires have load taken off them, they lose traction.

But here's the big thing: As this graph indicates, the more load on a tire does not result in a corresponding increase in traction. It's not a linear relationship – they gain grip, but not at the same rate as the load increases.

When you look at it from the perspective of all four tires on your car, the tires that gain more grip from the extra load don't gain as much as the unweighted tires lose. So, just when you need the traction the most - when going around a corner, for example - you actually have less traction. This has to do with the physics of how rubber tires interact and grip the track surface - and is beyond the scope of this ebook.

Traction Unit Number

To illustrate this concept to help you better understand it, I created this model of how tires, load, and traction work. I call it the Traction Unit Number, and it works like this (as shown in the illustration to the right): If you could measure the amount of traction each tire has when the car is balanced and traveling at constant speed down a straightaway, you would see that each tire has 10 "units of traction" (again,



this is a model, a concept, and not something that you can actually measure like this). But as you turn through a right-hand corner, weight transfers to the outside, or left side tires. They gain grip, resulting in, let's say, 15 units of traction. But the inside tires have lost traction, resulting in only 3 units of traction each. Overall, when the car is cornering, it has 36 units of traction (3+3+15+15=36), instead of the original 40.

Every time you brake, turn the steering wheel, or accelerate, you cause some amount of weight transfer, resulting in less traction than when the car was in a steady state and perfectly balanced. But the smoother you brake, turn, and accelerate, the less weight transfer you cause, meaning you have more traction to work with. That is why smooth is fast!

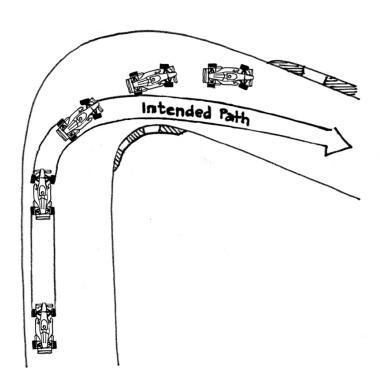


Handling Characteristics:

You hear the terms understeer and oversteer all the time, right? But what do they mean?

Understeer:

When the front tires have less traction than the rears do, the car tends to push or plow relatively straight ahead, rather than turning as much as you'd want it to. That's understeer. This is caused by either the car's setup, or you have caused the understeer by transferring too much weight to the rear. Therefore, the fronts don't have enough traction to change the direction of the car as much as you'd like. No matter what, look where you want to go.





Controlling Understeer:

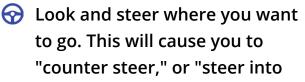
- Transfer weight to the front tires by easing your foot off the throttle. If you're not accelerating, it would make sense to brake to transfer weight forward, wouldn't it? That can work sometimes, but if the front tires are already beyond their limit of traction, then asking them to do some braking may actually make things worse. If you do brake, it better be very gentle and light.
- Be patient. Sometimes you just need to wait for the weight transfer from easing off the throttle to take effect, and for the car to have slowed enough for the front tires to grip the track enough to turn the car the way you want.
- Straighten the steering slightly. Yes, right when you feel you're going to plow off the edge of the track, you need to actually straighten the wheel and steer that way just a little. See, the front tires are at an angle that they can't grip the track with they're turned too much for the amount of traction they have. So the best thing to do is to unwind the steering just a little, to bring the front tires back to an angle that allows them to grip the track. This takes discipline and practice, because it goes against your sense of self-preservation.
- To summarize, look where you want to go, ease up on the throttle, and unwind the steering wheel slightly to manage understeer.

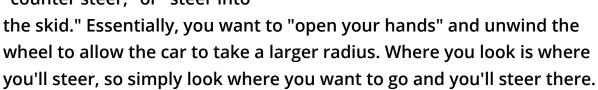


Oversteer:

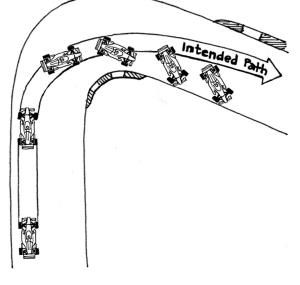
When the rear tires have less traction than the front tires do, the rear of the car will slide more, causing the car to turn - or steer - more than you wanted. Therefore, it has oversteered.

Controlling Oversteer:





- Often, you can transfer weight to the rear tires, giving them more traction, by gently accelerating. You'll need to be smooth with this because too much speed for the traction level of the rear tires is what caused the oversteer in the first place. Accelerating too much, or too aggressively, will increase your speed and make things worse.
- If the oversteer is caused by being too hard on the throttle, causing "power oversteer" (this can only be done in a rear wheel drive car), you'll need to gently ease off the throttle. If you lift too quickly, you'll transfer more weight to the front, making the oversteer worse.

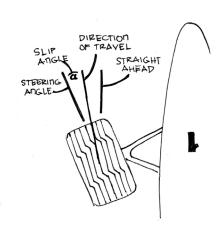




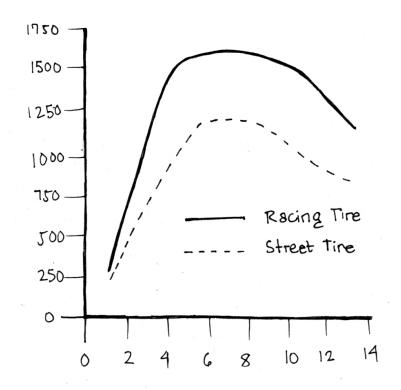
- There are times when you want a small amount of oversteer. For example, in a tight corner (a hairpin turn), you need the car to change direction a lot you need to get it to turn a lot, or rotate. Using weight transfer to the front as you turn into a corner will help the car rotate, or oversteer a little (just enough).
- Oversteer can be caused by either the driver, or the car's setup. If you don't manage the weight transfer properly, the car will oversteer. Or the combination of suspension setup, aerodynamic downforce balance, and tires can also lead to your car oversteering. It's important to learn how to identify each one, so you can "fix" the problem (and not something that you think is the problem).
- To summarize, look and steer where you want to go. Gently and smoothly modulate the throttle (to either transfer weight to the rear, or reduce the amount of power to the rear wheels) to manage oversteer.



A tire's slip angle can be viewed as the difference between the direction the tire is pointing and the direction the car is heading. When driving at the limit, there is a certain amount of slip. And almost ironically, tires generate more traction when there is some amount of slip (see the next illustration – Slip Angle vs. Traction graph).

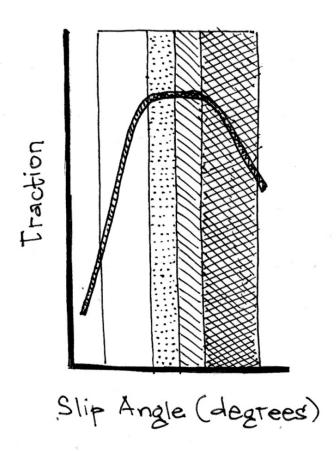


This graph compares traction/grip (on the Y-axis), to a tire's slip angle (along the X-axis). As you can see, as a tire's slip angle increases, it actually gains traction until it plateaus, and then falls off.



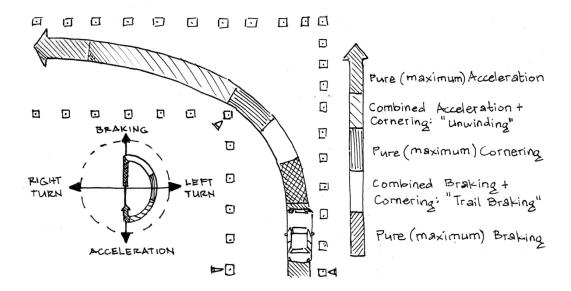


This Slip Angle vs. Traction graph shows 4 different drivers: The driver who spends most of the time in the far left band is driving at less than the limit. The one driving in the far right band is over-driving the car, spending too much time with the tires beyond their limit (note that this doesn't necessarily mean spinning or crashing – it can just be too much sliding through the corners). The two bands in the middle would result in the same speed around the track because they spend the same amount of time in the peak traction zone, but the middle-left band driver would be faster over time. Why? He's putting less wear and tear on the tires.

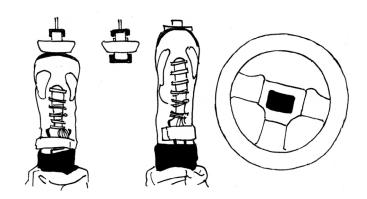




There's a lot going on in this illustration: on the left is a "Traction Circle" diagram, in the middle is a car being driven through a corner, and on the right are the corresponding actions – what the driver and car are doing. All are related. This is what driving the limit is all about, so take time to fully understand what's going on here.



There is a relationship, or interplay, between the steering wheel and the throttle and brake pedals. You're constantly trading off braking for cornering, cornering for braking, acceleration for cornering, and cornering for acceleration.

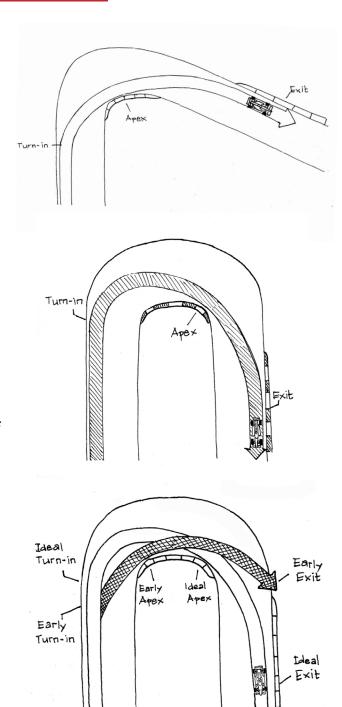




Every corner can be described by three reference points: the Turn-in, Apex, and Exit (sometimes called "Track-out"). At its simplest, keep two goals in mind: Straighten the corner out as much as possible, and drive it in such a way that it allows you to begin accelerating early (the speed on the straight after the corner is usually more important than the speed you drive through the turn).

Here's what the three reference points look like in a hairpin corner. It also shows how you want to use all the track, entering from the outside edge of the track (at the Turn-in point), to the inside at the Apex, and then back to the outside edge at the Exit.

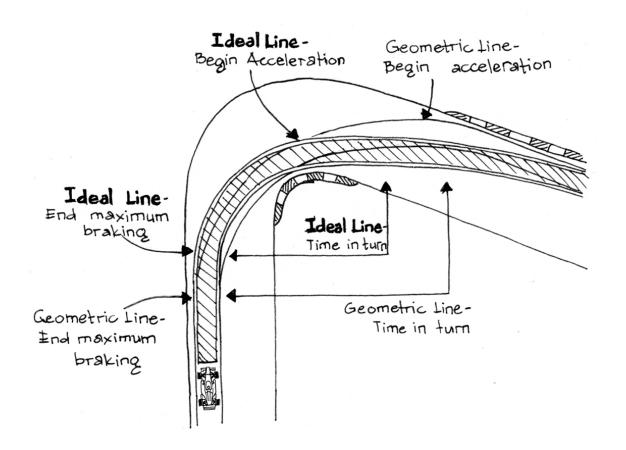
As you can see from this illustration, if you turn in early, you'll clip an early apex, and ultimately "run out of track" at the exit. Your Turn-in point is critical, so having a good reference point for it is key.





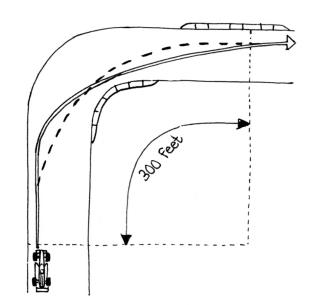
This illustration really captures the benefits of a "late apex" (or "Ideal Line"):

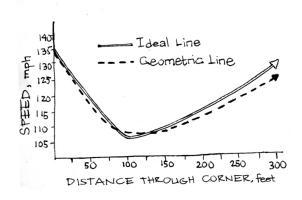
1) It allows later braking, since you're going to turn in later; 2) You spend less overall time in the corner, and that means more time spent accelerating; 3) It means you can start accelerating earlier; and 4) It allows you to see, or "peek" around the corner better (not really indicated here, but it's an important benefit).



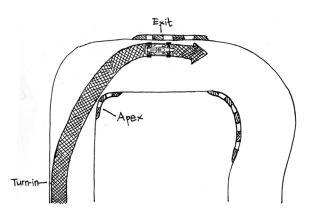


Here's another look at the reason for a later apex line. The dotted line demonstrates the geometrically-largest radius – which is the fastest way to drive through the corner in isolation - but as you can see, you spend practically all of the 300 feet cornering. Until you begin unwinding/straightening the steering wheel, you can't start to accelerate. By turning in and apexing later, it allows you to accelerate earlier, meaning you'll be faster on the following straightaway. As the speed trace diagram shows, you will be a little slower at the beginning of the corner, but you'll more than make up for it later in the corner and down the straightaway. This is why the late apex line is referred to as the "Ideal line."



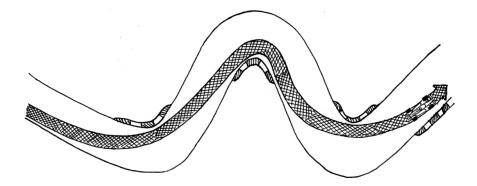


If you have a corner with very little straightaway after it (like Turn 6 at Road Atlanta), your focus should be on carrying as much speed into it, and not worry so much about exit speed. There are very few corners like Turn 6, so don't get carried away with this!

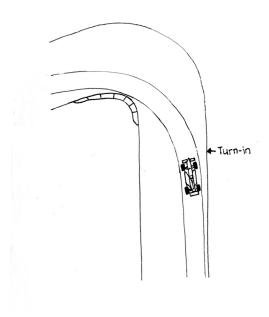




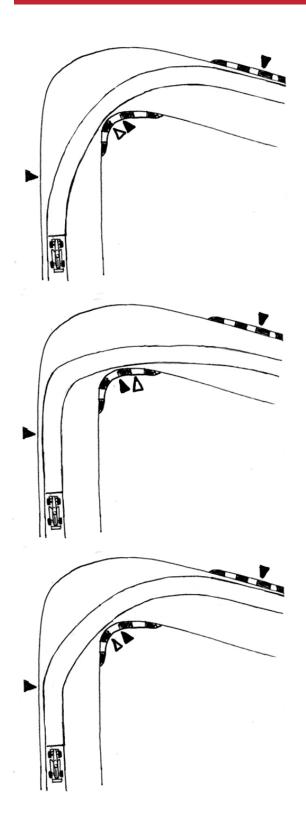
Here's how you would approach and drive a series of corners, like Esses. The lesson here is that you'll have to compromise at least one corner to maximize your exit out of the final corner. In other words, your priority should be how quickly you get out of these corners.



Here, I'm illustrating how NOT to do it. This driver is "crabbing" into the corner, pulling the car away from the edge of the track before the Turn-in point, reducing the radius of the corner – meaning the car will not be able to carry as much speed through the corner.





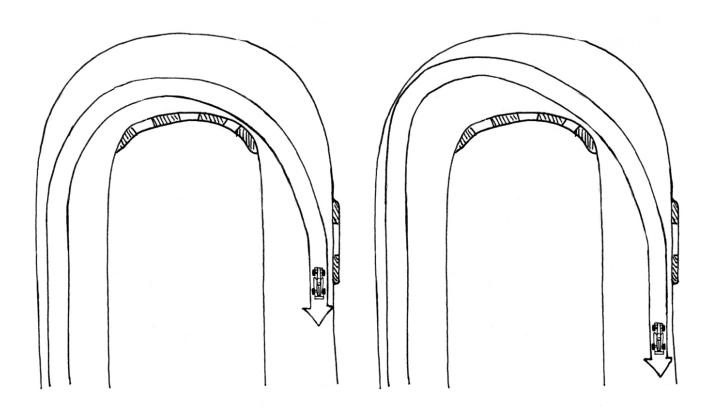


Here are three more errors illustrated to help you learn from them. In the top illustration, the driver has turned in too early (before the Turn-in point), resulting in an early Apex. The driver would have to delay beginning to accelerate to avoid driving off the track.

In the second illustration, the driver has turned in too late, now having a late Apex. While safer than the previous mistake, the amount the driver would have to slow down would be impossible to make up for – the driver would be slow down the straightaway. The key indicator here is that there is room between the car and the edge of the track at the Exit – there is no need to use all the track. Next lap, the driver should aim to turn in at the right point and clip the ideal Apex.

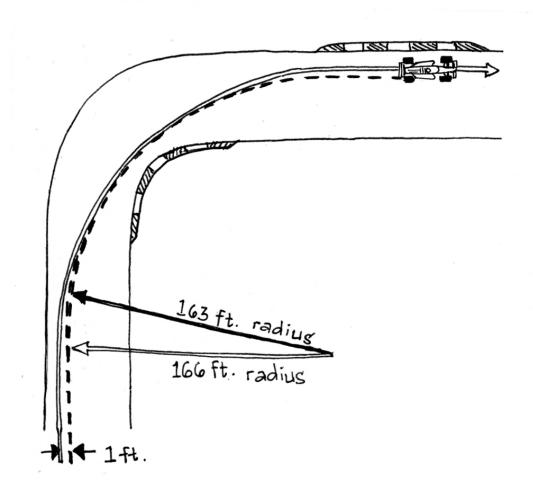
In the third illustration, the driver turned in at the right place – at the Turn-in point – but he turned too abruptly, too sharp, resulting in an early Apex. Ultimately, it ends up very similar to the first illustration above – delayed acceleration to avoid running out of track at the Exit.

Here's a comparison of two lines through a hairpin turn, one with a fairly standard late Turn-in and Apex, the one on the right with a more exaggerated "late apex" line. Which is best? That depends on track conditions, how the car handles, and the car's acceleration capabilities. If it was raining, the second option might be better, providing a straighter line to accelerate on. If the car had little power, the momentum one could carry through the corner with the first option might be better. The lesson here is that you need to experiment with the lines you drive to find the ideal compromise.

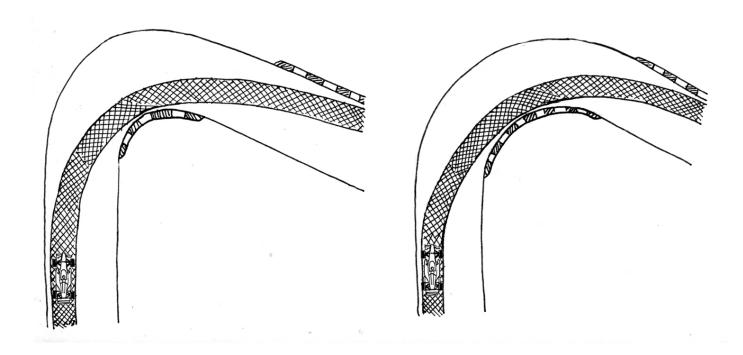




Not using all the track width is a big no-no, and even being one foot away from the edge of the track as you enter a corner can have a big negative impact - it reduces the radius of the turn more than you might imagine. You paid to use the track – use it all!

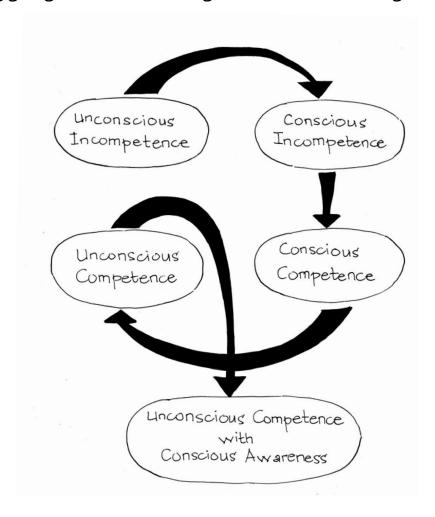


The differences in the line you drive can be subtle, as this illustration demonstrates. The corner on the left is a slightly tighter radius than the one on the right, so it requires a later Turn-in and Apex line. However, both of these illustrations are showing early Turn-ins – both would benefit from a later Turn-in and Apex to maximize straightaway speed.



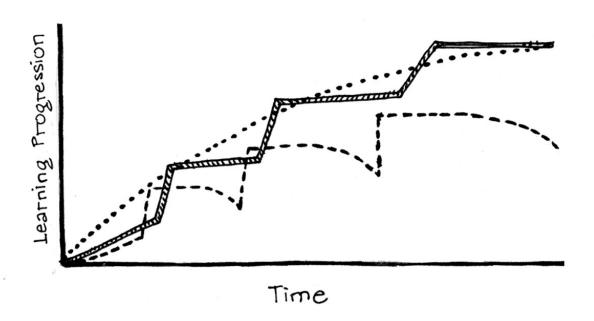


Learning theory tells us there are four stages to mastering an activity: Unconscious Competence (you don't know what you don't know); Conscious Incompetence (you know what you don't know); Conscious Competence (you know what you're doing, but you're having to think about it); Unconscious Competence (you no longer have to think about it – you just do it). I've added a 5th stage that I think describes what "being in the zone" is: Unconscious Competence with Conscious Awareness (you don't have to think about the mechanics of doing something, but your conscious mind is fully aware of everything going on, and is thinking about how to do things even better).

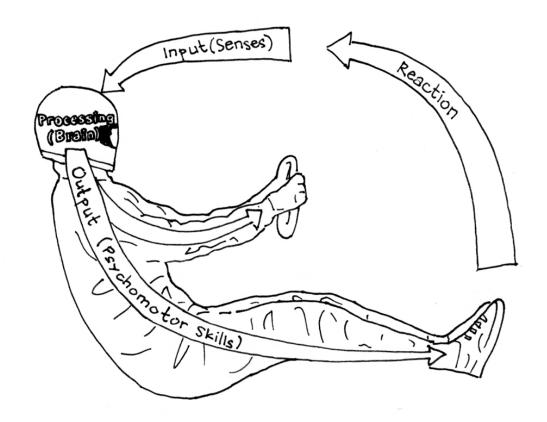




People talk about the "learning curve," as if we actually learn on this smooth path. But we don't. Instead, we learn in steps: We make progress, plateau for a while, make another step of learning, plateau, and so on. That is, unless we get frustrated when on these plateaus, resulting in a digression in learning. The lesson here? Be patient if you're on a plateau, as there is a burst of learning after every one.

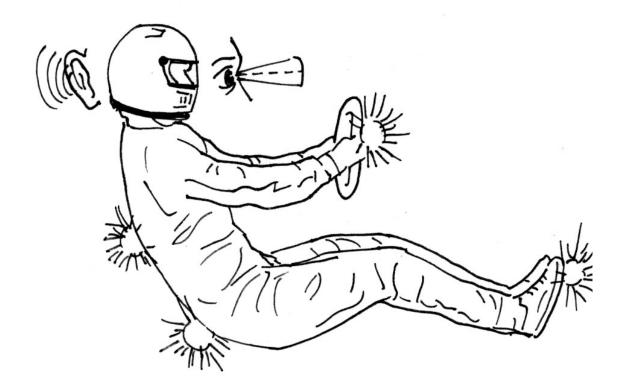


As you drive, information is taken in through your senses, processed by your brain where it tells your body what to do (brake, turn the steering wheel, squeeze the throttle, turn your head to look through a corner, etc.) – the output – and then you react to those actions. This loop/process happens over and over, thousands of times per second, and as you improve, it happens faster and more efficiently.

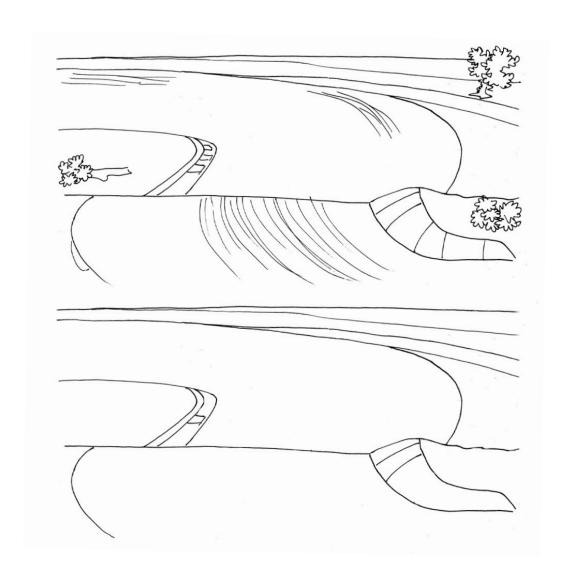




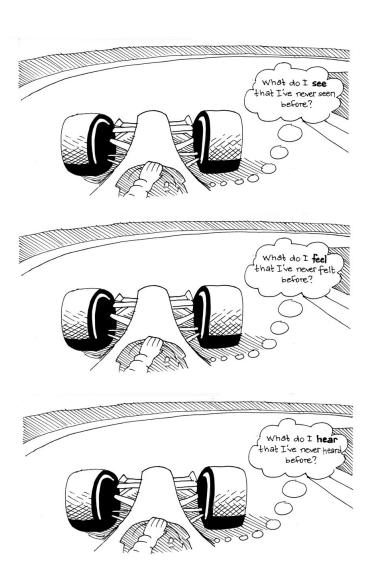
On track, you're picking up information through your visual, kinesthetic (touch, balance, sensing g-forces pushing against your body), and auditory senses. The better the quality of this information, the better you'll drive.



Here are two views of the same section of the track, and what two different drivers pick up with their senses (in this example, visually). The driver in the top scene sees more; the driver in the lower scene misses what the driver at the top sees. Which driver do you think is faster? Which driver do you want to be?

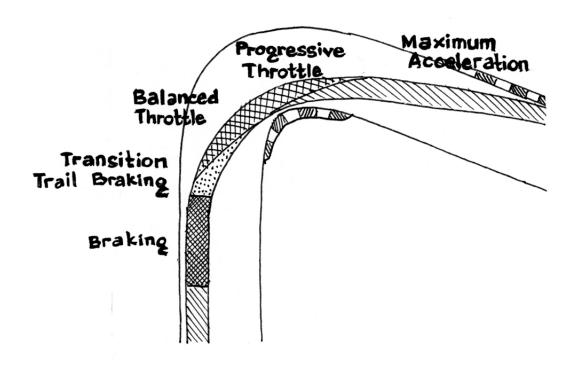


If you take time to focus solely on taking in more sensory input – visual, kinesthetic, and auditory – you'll be giving your brain better quality information to work with. Better quality information results in a better output, a better performance. When you specifically and deliberately spend time on the track to focus on these senses, one at a time, you're doing what I call Sensory Input Sessions. The results are very powerful.



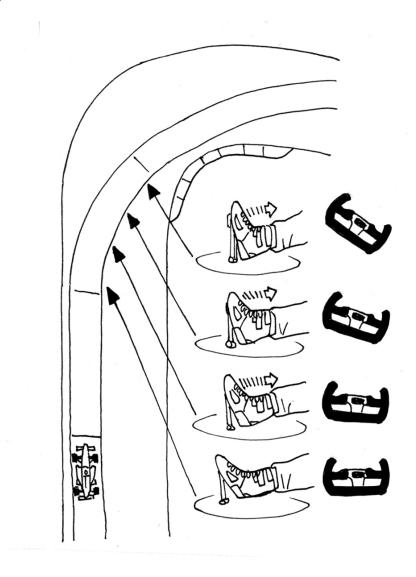


Putting together what I illustrated in the Vehicle Dynamics and Cornering sections, here we see the Ideal Line and what you're doing when driving it.



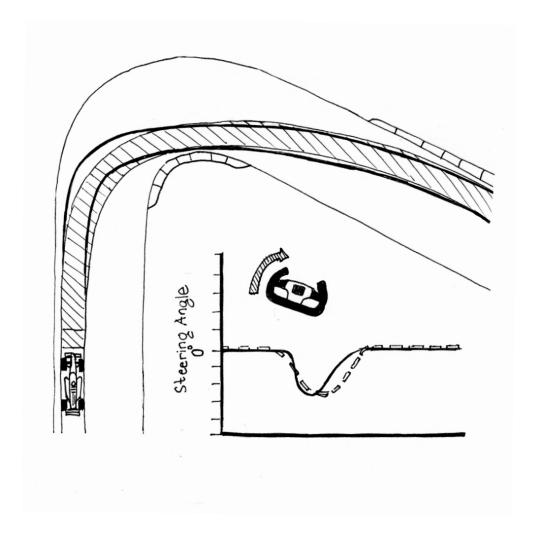


Here's an illustration of Trail Braking. You can think of trail braking as simply "trailing" (slowly releasing) your foot off the brake as you turn into a corner, trading braking force for cornering force. You can see how there's a trade-off of braking for steering angle. This keeps the tires at their maximum traction levels, and can help you change the direction of your car into the corner by keeping weight loaded on the front tires.



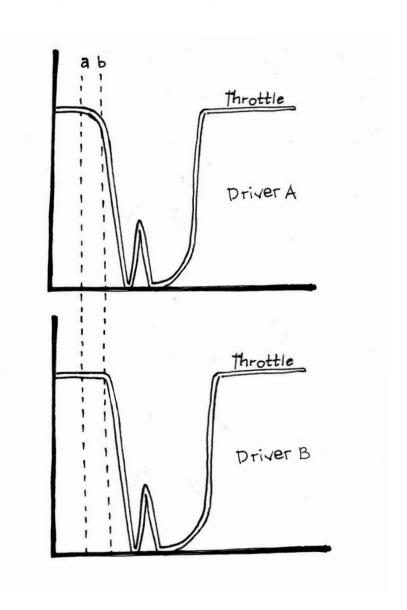


There's no absolute right or wrong way to turn into a corner, or even just one perfect line through it. It depends on many factors: the type of car and how it handles, track conditions, driving style, and the shape of the corner. This illustration should get you thinking about how a later Turn-in requires a sharper turn of the steering; an earlier Turn-in makes for a more gentle turn of the wheel. Which is best? You have to experiment with both to find out.



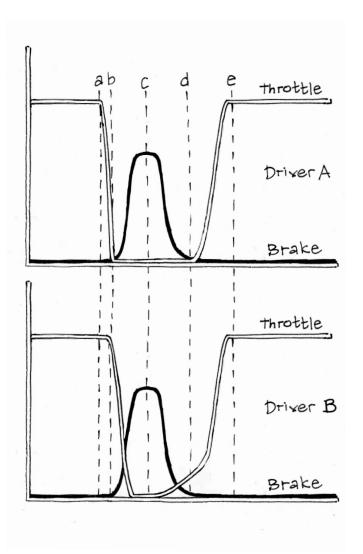


Here, I'm illustrating a trace of the throttle position (as we'd find with a data acquisition system), and comparing two drivers. In the upper graph, you can see the driver slowly releasing the throttle; that will cost speed compared to the driver in the lower graph. It may seem like there would be very little difference, but in reality, it can make a significant difference.



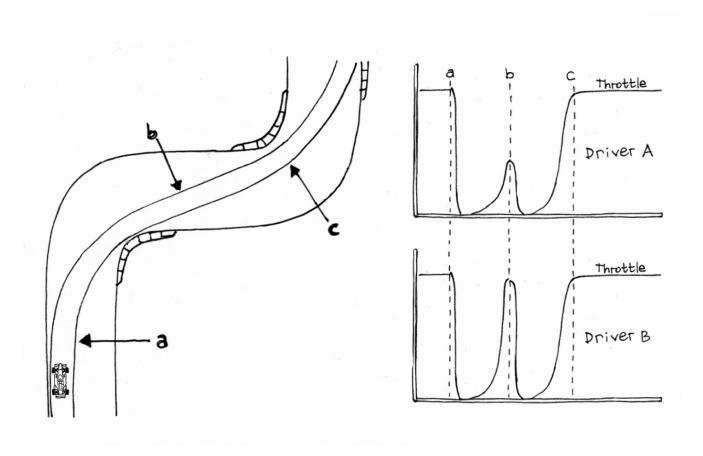


I use this illustration to show the benefits of left-foot-braking (Driver B in the lower graph) over right-footbraking (Driver A, in the upper graph). The dark, solid line is brake pedal pressure, and the light/double line is throttle position. Because there is a finite amount of time that it takes to lift the right foot from the throttle and move it over to the brake pedal, Driver A must lift at Point "a," whereas Driver B is able to lift his right foot from the throttle at the exact same time (Point "b") as he begins braking with his left foot. Also note that Driver B is able to overlap braking and acceleration a little bit (you can overdo this, so be careful with it). Not all cars can be left-foot braked, and I'm not saying all drivers should, even if they can, but it's something to consider.





When I talk about "hustling" a car, I mean looking for opportunities to get to 100% full throttle, if even for a fraction of a second. In this illustration, it's at Point "b," in between two corners. Many drivers will do as Driver A has here, and give it partial throttle. In the back of their mind, they're thinking, "Well, I'm going to have to lift again for the next corner, so there's no point in giving it full throttle here." That's at a subconscious level, and the driver is probably unaware they're doing it (that's why a data acquisition system can be so valuable). Look for "hustle" areas.



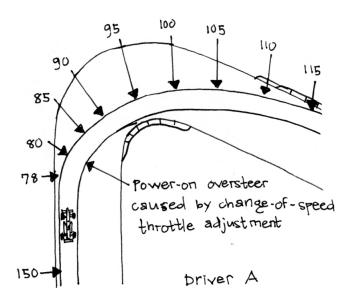


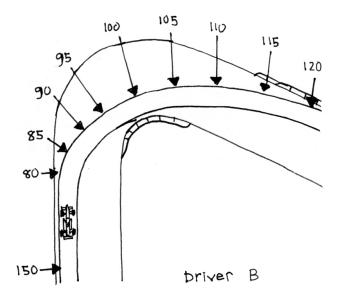
Driving over Apex curbs allows you to straighten the corner out, increasing its radius, meaning you can carry more speed through it. Of course, not all curbs and cars are created equal. Some curbs are meant to be driven over, and some not; some cars soak up curbs, and others don't. Experiment.

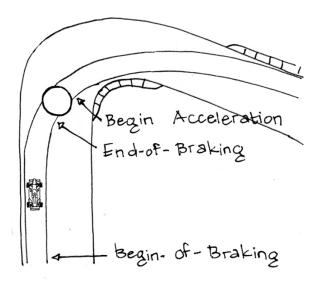


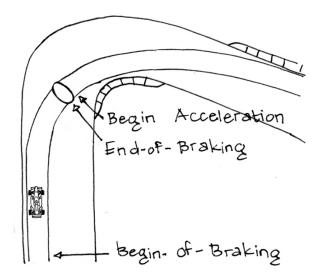


This illustrates what I call the "Change in Speed" problem. Driver A slows the car to 78 MPH on the entry to the corner, while Driver B enters at 80 MPH. Let's assume 80 is the limit. Even though 78 MPH is below the limit, it's close to it. As Driver A enters the corner, he senses that the tires are not quite at their limits, so he accelerates to get the car to its limit. This causes the car to either understeer due to the rearward weight transfer, or some power-on oversteer. Either way, the driver interprets this as he's driving the limit, and so he continues to enter at 78. In the meantime, Driver B carries 80 MPH into the corner, smoothly transitions to acceleration at the right time, and begins accelerating from a higher speed. I don't need to tell you which driver is faster.









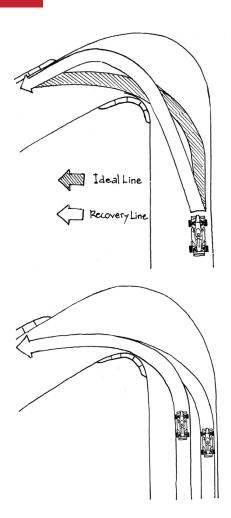
Most drivers focus on the Begin-of-Braking point - that reference point on the straightaway approaching a corner that tells him where to start braking. The best drivers, though, focus more on the End-of-Braking (E-o-B) point, where they finish braking and their foot has come completely off the pedal. This does three things: First, it forces you to look into the corner, which is always a good thing. Second, it results in a smoother brake release, therefore balancing the car better, and meaning you're able to carry more speed through and out of the corner. Ultimately, it will result in less "nothing" time in between your brake release and start of applying the throttle. And finally, by looking into the corner, to the E-o-B point, you're likely to brake slightly later, but be more calm and relaxed when doing so, because you know where you're going.



Okay, you've made a big mistake (or the brakes are failing in your car), and you're carrying way too much speed into a corner. Rather than riding it out and likely spinning or crashing off the track, adjust your line to lengthen the amount of time you have to slow the car down by using the "Recovery line."

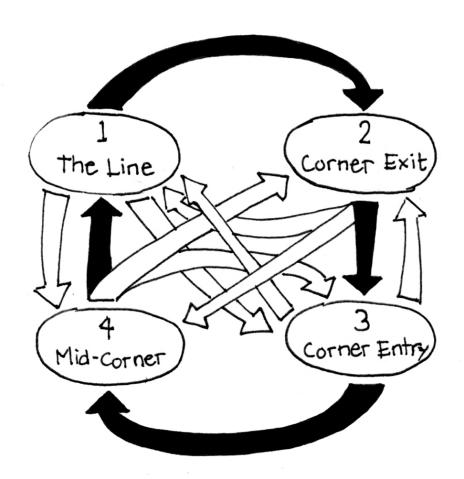
When passing another car, a goal should be to get back on the Ideal Line as soon as you can. If you're out-braking another car on the inside into a corner, preferably you'll merge back on the line by the Apex, and focus on accelerating out of the corner from there.

This illustration also demonstrates "presenting" yourself to the driver you're passing. In this case, the driver on the inside is well up, and even a little beyond, being alongside the other car. There's no doubt who controls the corner.



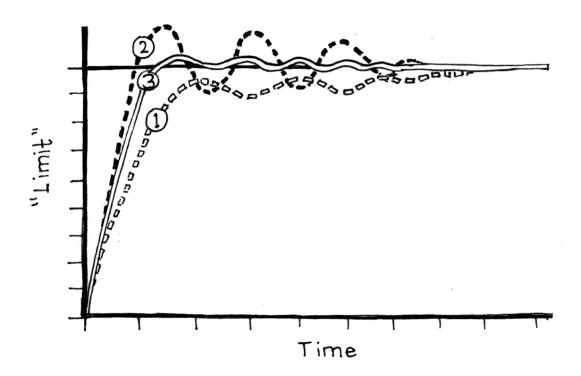


When you first start learning to drive on the track, your first focus is on following the right line. As you begin working on going faster, you should target your corner exit speed, then your corner entry speed. As you put those together, your mid-corner speed will naturally pick up. It's at this point that the one change you made to improve your exit speed, for example, will impact your line, and that will change your corner entry speed, and so on. It's this constant learning and fine-tuning that makes this sport so challenging and fun!





To consistently drive at the limit, you're going to need to go beyond it every now and then. Your goal, though, is to go over it just a little, as illustrated by Driver #3's progress. Driver #2 is going over it (and under it) too much; Driver #1 never reaches it.



FINAL THOUGHTS

Once again, the purpose of the illustrations in this eBook is not to explain every detail. The purpose is to make you think, and to provide quick reminders and refreshers. Between sessions at the track, or the night before a day at the track, flip through this eBook – think and refresh.

If you'd like to make suggestions for future updates, or you have questions, please email me at ross@speedsecrets.com.

I definitely have more to share on other topics, though:

- What I believe to be the most important piece of training I offer is a series of eCourses at Learn.SpeedSecrets.com. It begins with Performance Driving 101 and goes to Inner Speed Secrets 201. And I'll be adding other courses over time.
- You can never learn too much. One of the best ways I know how to stay on top of your driving game is to subscribe to Speed Secrets Weekly at SpeedSecretsWeekly.com. It's "entertaining education, conveniently delivered."
- Follow and contribute to the Speed Secrets Facebook page at <u>Facebook</u>. com/DriverCoach.
- Subscribe to my YouTube channel at YouTube.com/SpeedSecrets1. I post driving tips there on a regular basis.



FINAL THOUGHTS

- I have more driving tips available at SpeedSecrets.com, along with eBooks about shock tuning (Shocks For Drivers), and using mental imagery to improve your driving (Mental Imagery Guide).
- I love doing seminars, presentations, and talks for car clubs and other organizations. If you'd like information about this, go to SpeedSecrets.com/presentations.
- If you're interested in my coaching services, learn more at SpeedSecrets.com/coaching.
- If you're a HPDE instructor (or are thinking about being one), download the free Brake, *Brake*, BRAKE!: The HPDE Instructor Manifesto eBook at HPDE-Instructor-Tips.com.



FINAL THOUGHTS

There are two themes that I've lived my driving and coaching life by, and they've done me well:

- 1. There's always more: I can always learn more, and improve as a driver. You can always learn more, and improve as a driver. That's what makes this sport so much fun.
- 2. Be The Source: With Speed Secrets, I strive to be the most complete source of information and training for performance and race drivers, for beginners to elite-level pros, from free tips and advice to one-on-one coaching.

I hope I'm able to continue to help you learn more about, and enjoy, performance driving.

Have fun!

