High Performance Drivers Manual

1994 Update

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High Performance Drivers Manual - 1994 Update by Allen G. Heubner

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Class I

I. Secrets of High Performance Driving

II. Preparing to Drive

A. Car Interior (Loose Objects)
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I. Secrets of Successful High Performance Driving

The three secrets of high performance driving are:

Smoothness, Smoothness and, Smoothness.

If you were to watch a good driver drive fast (or otherwise), his or her steering inputs, acceleration, braking and shifting might, at first blush, appear violent. Perhaps they are but, they are smoothly violent and certainly no more violent than is absolutely necessary.

Upon closer examination of this driver, you would discover, however, that he or she makes no unnecessary movements of the steering wheel which would unbalance the car by shifting weight back and forth on the vehicle's suspension. The steering wheel is turned only as quickly and only as far as is absolutely necessary to place the vehicle on the desired path. Brakes are not applied, released and reapplied causing the car to bounce back and forth on its suspension. Rather, the brakes are applied once, progressively and swiftly until the vehicle attains the desired speed, then smoothly released. Downshifts are imperceptible except for the change in the pitch of the engine. There is no lurching, squatting, or bouncing of the vehicle as the lower gear is engaged. Application of the throttle is smooth and progressive, unaccompanied by throttle-on throttle-off antics which would also upset the vehicle's delicate balance.

Good driving consists of proper use of the steering wheel and footwork.

The rest of this manual contains the information you need to help you become smooth, smooth, and smooth. You, however, must supply the discipline and determination necessary to put the information to work for you.

II. Preparing to Drive

A. Clean Interior

It is imperative that all loose objects, and any objects which might become loose, are removed from the interior of your car before venturing out onto the track. CHECK UNDER THE FRONT SEAT—objects tend to gravitate to this area and are forgotten until the first time the brakes are applied vigorously whereupon they roll, slide, or rocket out to take up residence in or about your feet.

It's bad enough carrying loose objects in your car on the street, but on a racetrack, the hazards are magnified. Aside from getting in the way at the wrong time, these items can become lethal projectiles, particularly in an accident. NEVER CARRY ANYTHING ON THE SHELF UNDER THE REAR WINDOW (on or off the track).

We also recommend that you remove the floor mats to avoid the possibility of getting tangled up in them or their moving and interfering with the pedals.

B. Tire Pressure

People who have auto-crossing experience tend to inflate their tires to very high pressures (I've heard conversations of as high as 40 psi). These high pressures might be fine for auto-crossing (only a tire pyrometer will guide you to the optimum pressure) where the car is on the course for only about a minute but it's too high for a race track (or the street).

Due to cornering, braking, and accelerating forces on the tire, heat transfer from the brakes and the length of time spent on the track, the tires will get hot. As they heat up, the air in the tire expands resulting in an increase in tire pressure.

If you start with 40 psi cold pressure, you may end up with eye popping inflation during a track session. Start with around 35 psi all around. When you begin cornering, the tires may feel a bit mushie—that's where the warm up comes in (discussed later). As the tires heat up and the pressure rises the tires should begin to feel very good.

C. Sitting in the Driver's Seat

Performance driving does not permit the driver to be a loose object in the car. To control the car you must be firmly installed behind the steering wheel in a manner which permits your legs and arms the maximum range of motion and leverage. To achieve this, you must first sit in rather than on the seat. Use your feet to push yourself into the seat. Wiggle your behind to burrow down into the seat.

After you are sitting in the drivers seat, with your back against the seat back, check to make sure you can reach all the pedals—if not, adjust the seat forward until you can, and burrow back down into the seat.

Now, keeping your back against the seat back, reach forward and place your hands on the steering wheel at the 3 and 9 o'clock positions, see Figure 1.

Look at your arms. They should be slightly bent. If your arms are fully extended, you're too far from the steering wheel (except, perhaps, if you're driving an Italian car). Sitting too far back will cause you to lean

forward and out of the seat back in order to steer or shift, which in turn will cause a tendency to use the wheel as a brace during hard cornering. Adjust the seat closer to the steering wheel or, if you need the leg room, tilt the seat back, forward.

Next, remove your right hand from the 3 o'clock position and place it on top of your left hand at the 9 o'clock position. If you are able to do this without your back moving away from the seat back, and, assuming both of your arms are the same length, you're on the right track, but you still must make certain that you are not sitting too close to the steering wheel.

Place your hands back on the steering wheel at the 3 and 9 o'clock positions. Remember, your arms should be bent slightly. Turn the steering wheel to the right and then to the left without moving your hands from the 3 and 9 o'clock positions. If when you do this, your elbows hitting the seat back or your body, you are too close to the steering wheel. Tilt the seat back, back until your arms are just slightly bent. Short people may never be able to obtain the proper seating position without modifying the car, i.e., extending the pedals with blocks. If you're short, just try to find the best compromise between reaching the pedals, slightly bent arms, and being able to see over the dashboard.

D. Mirrors and Gauges

Before attaching your seat belt, adjust your rear view mirror and side mirrors. WHILE DRIVING ON THE TRACK. YOU MUST CONSTANTLY MONITOR YOUR MIRRORS. This should be your regular practice whenever and wherever you're driving. You must constantly be aware of what's going on around you—to accomplish this, you must use those mirrors. On the track, you need to be aware of traffic that may wish to pass you. Since you'll be pretty busy in the corners, you won't have time to check the mirrors, but check them several times on each straight away. In addition, while on a straight away, check the engine function gauges or warning lights—engine temperature, oil pressure, and charging system (a malfunctioning charging system may mean that the fan belt has broken). Forget about the Speedometer.

E. Seat Belts

We stated earlier that you must be firmly installed behind the steering wheel. If your car is equipped with a competition harness, it's no problem-just cinch down the lap belt and tighten the shoulder belts until they hurt (a little pain will keep you alert). If you're considering installing a competition harness in your car, a four-point system (two lap and two shoulder belts) is a waste of money. With a four-point system, when the shoulder belts are properly tightened, the lap belt will raise up and will end up around your midsection. Buy and use an antisubmarine strap (it mounts on the car floor, runs between your legs, and attaches to the lap belt) as well as the lap and shoulder belts. It will hold the lap belt in the proper position—around your pelvic bone and hips. If you don't have a competition harness, all is not lost. Attach the OEM* belt/shoulder harness and crank the seat back down. While you're staring at the roof of your car, grab the shoulder belt and give it a violent jerk to fool it into thinking you've just been in an accident. The inertia system will lock. Once it's locked, lean your body forward against it to hold it in the locked position and at the same time crank the seat back, back up to your driving position. You are now installed behind the wheel.

*Original equipment manufacturer.

F. Holding and Turning the Steering Wheel—Part I

Both hands please. One hand may be removed to change gears or signal another to pass, but once accomplished, it is to be returned to the wheel. NO ONE HAND DRIVING. It is very difficult to obtain the smooth, accurate movements of the steering wheel required in high performance driving using only one hand.

The car is to be driven with your hands at the 3 and 9 o'clock positions. If your steering wheel permits, hook your thumbs over the spokes. The steering wheel, like a golf club is held lightly but firmly with the fingers. (Your fingers are more sensitive than the palms of your hands.) If you hold the wheel with a death grip, you'll cut off your circulation and you won't feel anything. In addition, gripping the wheel too tightly will inhibit smooth precise movements of the wheel. To turn the wheel, pull down rather than pushing up (i.e., for a right turn, pull down with your right hand rather than pushing up with your left).

The 3 and 9 o'clock positions should permit you to make most turns on most tracks without getting your arms fully crossed. Your arms should never become fully crossed because if you discover that more lock is required, you won't be able to do it. (Lock is any change in steering wheel rotation. It does not necessarily mean turning the wheel as far as it will go.)

If a turn is so sharp that it cannot be navigated with hands at 3 and 9 o'clock, two acceptable solutions exist. (Neither of which requires removing your hands from the steering wheel.)

First, you can change the position of your hands on the steering wheel before you reach the turn. For example, if you're approaching a sharp right turn, slide your right hand up the steering wheel to one o'clock, your left hand to 7 o'clock and pull down with your right hand to make the turn. After the turn, slide your hands back to 3 and 9.

Alternatively, you can slide your right hand to one o'clock as you approach the turn and leave your left hand at 9 o'clock. As you turn the wheel, let the wheel slip through your left hand until the part of the steering wheel directly opposite your right hand is by your left hand. Now close the grip of the left hand and complete the turn using both hands. When you unwind the wheel, again let the wheel slide through your left hand until the 9 o'clock position comes around and close your grip. You can, by moving your right hand all the way over to your left hand, get one full right revolution of the steering wheel. It is not unlikely that you will feel uncomfortable holding and using the steering wheel correctly. After doing it incorrectly for many years, it's bound to feel uncomfortable but stick with it and unlearn your bad habits. If you really want to become a competent high performance driver, the correct use of the steering wheel is important.

G. Warm-Up

1. Novice Drivers. Drive the first several (at least two) laps of each of your track session at a conservative pace to allow your car, its tires; and you time to warm up.

2. Intermediate and Advanced Drivers. Need to warm-up also. During your warm-up lap or laps, drive at a conservative pace but, use the brakes very hard, enter the turns at a relatively slow pace but turn in hard and accelerate hard out of the turn. In addition, pinch the car in a little at the exit of the turn (i.e., don't unwind the steering wheel as much as you normally would coming out of the turn).

H. Cool Down

At the conclusion of each track session, you will be given a cool down lap. USE IT TO COOL DOWN—yourself and your car. Slow down, use the brakes as little as possible to assist in their cooling off. DO NOT TURN-OFF YOUR BRAIN. The cool down lap can be extremely dangerous because, compared to your speed on the previous lap, it will feel like you're traveling very slowly. YOU'RE NOT! You're still traveling quite fast so PAY ATTENTION.

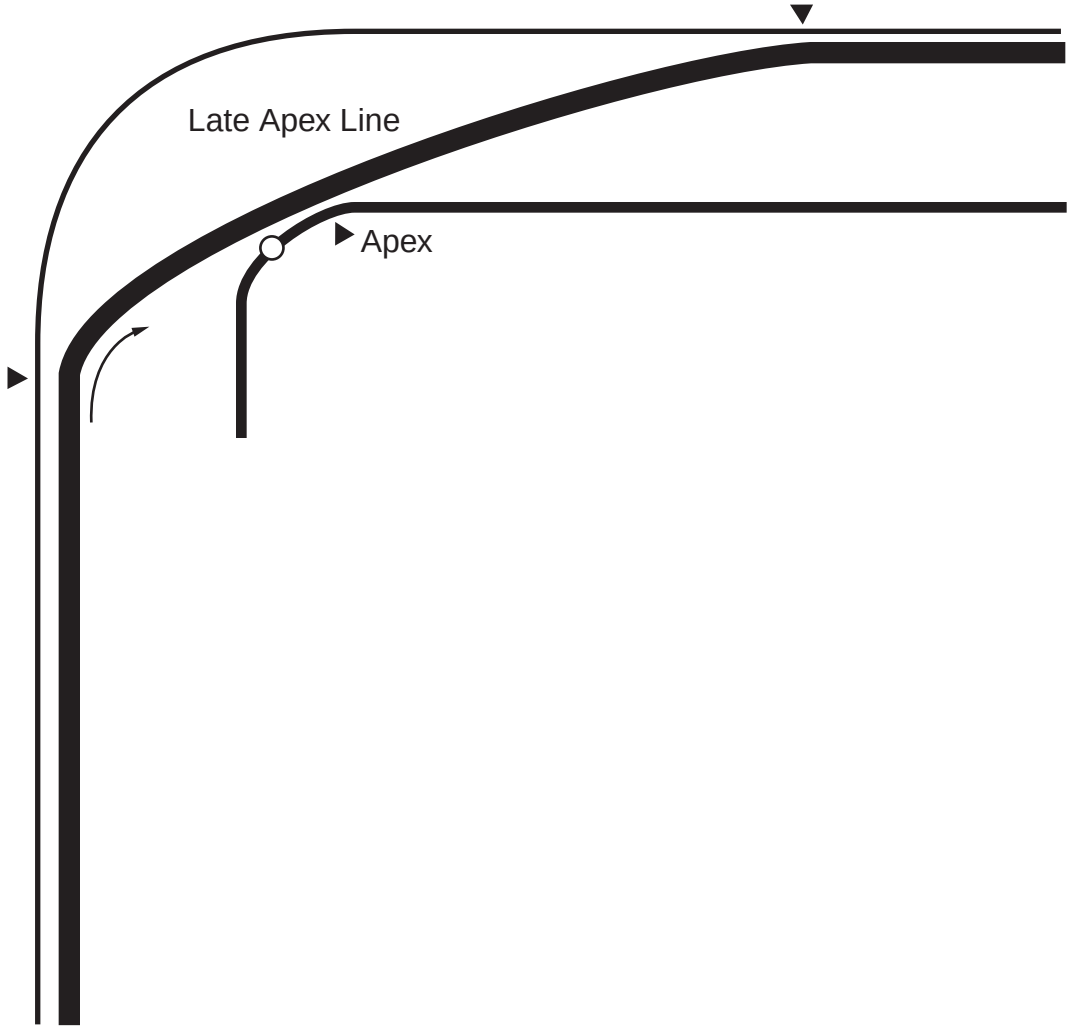
When you finally stop your car in the pit lane or paddock, DO NOT SET THE EMERGENCY BRAKE. DO NOT HOLD THE BRAKE PEDAL DOWN WHILE THE CAR IS STOPPED. At this point, your brake rotors are hot and getting hotter. Doing either of the above may warp the brake rotors—or worse.

III. The Line—Preliminary Discussion

The line is the path described by a vehicle as it travels on a road.

The correct line through a corner will always involve using all- of the available roadway. This, and the other information in this manual, is applicable no matter where you're driving. For example, the correct line doesn't change, only the amount of roadway available to you changes. On a race track, the entire roadway from one shoulder to the other is available; whereas, on a public road, only a single lane may be available to you. Keep this in mind so that when you complete this performance driving school you can apply the principles you've learned to your everyday driving.

The "correct line" will always (well, almost always—but for now always) involve starting any turn from the extreme outside edge of the roadway, then touching the extreme inside edge of the roadway and finally touching the extreme outside edge of the roadway as you exit the corner. Since a picture is worth a thousand words, refer to Figure 2. The point on the inside edge of the roadway touched by the car as it travels through the turn is called the ***Apex.***



For this school, we have identified these important points on the track for you by placing pylons at the correct turn-in point, the Apex, and in most cases, the correct touching point on the outside of the roadway at the exit of the turn.

IV. Cornering

Later we will discuss Apexes, the Correct Line, and the whys and wherefores ad nauseam, but during your first track session all you need to do is drive on the extreme outside of the track surface as you approach a turn (the outside is the side opposite the direction of the upcoming turn, i.e., if the turn you're approaching is a right-hander, then the left hand side of the roadway is the outside and vice versa), turn into the turn at the turn-in pylon (it will be the first pylon you encounter as you approach the corner), touch the edge of the roadway at the pylon marking the Apex (the second pylon), and touch the outside edge of the roadway at the exit pylon. If you do this correctly, the line you will be driving will be the fastest and safest route through the corner. It is called a Late Apex line.

To drive the line that we have laid out for you, you must not:

1. Turn in too soon, i.e., before you reach the turn-in pylon;
2. Move away from the outside edge of the roadway before you reach the turn-in pylon. In other words, don't even think about starting the turn until you reach the turn-in pylon;
3. Fail to put your car right on the edge of the roadway at the Apex. (Don't worry if you hit the Apex cone.);
4. Drop a tire or tires off the roadway.

A. Braking

As you approach the turn in pylon, you will, in most cases, need to get the car slowed down. Only the brakes should be used to slow the car. Downshifting, while it might seem neat, should not be used to slow the car. Brakes are cheaper and more effective for the purpose than transmissions and clutches.

The proper use of the brakes requires that they be used as hard as possible over the shortest possible distance. Hard means that the brakes must be applied hard enough for the wheels to reach a point just short of locking up (i.e., stopped). This is called threshold braking. The brakes must be applied smoothly and progressively (squeeze the pedal down) to a point just short of lock up. The slower the speed of the vehicle, the more pressure can be applied to the pedal without locking up the wheels. Therefore, always squeeze down on the pedal. Never, never slam your foot down on it. You don't want to lock up the wheels, because, at anything over 35 mph, stopping distances will be longer, you will be unable to steer resulting in a loss of control, and you will cause a flat spot on your tires. If the car you are driving is equipped with ABS brakes, you need not be concerned with locking the wheels. The ABS system prevents this for you.

If you do lock up one or more wheels, back off the brake slightly until the wheel again begins to rotate, then squeeze down again.

If you are good at braking, the tires will make noise.

DO NOT SLAM ON THE BRAKES (this will cause the wheels to lock). DO NOT PUMP THE BRAKES (unless you find you have none. Pumping will sometimes bring back enough pedal to get you slowed down enough to avoid disaster. Once you have pedal, however, use them as discussed above).

FINISH ALL BRAKING WHILE THE CAR IS TRAVELING IN A STRAIGHT LINE.

The brakes should be used very hard early on as you approach the turn in pylon, less just before reaching the pylon and even less or not at all right at the pylon. The idea here is that you want the transition from full braking to no braking to be gradual. Remember, as you brake, weight is transferred to the front tires and when the brake is released, weight is transferred to the rear tires.

You should be aware that sometimes the brakes are continued very slightly as the car is turned into the corner. This is called Trail Braking or Trailing the Brakes. Now forget it for the present and finish all of your braking in a straight line.

You may find that at first you have difficulty braking very hard and releasing the brakes just before the turn in point and also driving the correct line. If so, since it is more important (at this point) that you drive the correct line, slow down until you can do it correctly.

B. Turing the Steering Wheel—Part II

To turn the wheel always pull down rather than pushing up. For example, in a right turn, pull down with your right hand rather than pushing up with your left. When your car reaches the turn in pylon, the steering wheel motion required to get pointed toward the Apex must be one continuous, smooth motion. Avoid turning the wheel too little or too much so that corrections will not be required in order to hit the Apex. This will take some practice. At the apex, you must begin to unwind the steering wheel in one continuous, smooth motion so that the car touches the edge of the roadway at the exit pylon. In high speed performance driving, the steering wheel should be moved as infrequently as Possible and no more than is necessary to put the car where you want it. The less the steering wheel is moved, the faster the car will go. No sudden herky jerky steering inputs. When you're driving slowly, you can make these mistakes without getting into trouble, but when you're driving near the limits, mistakes can be costly (or worse). LEARN TO DO IT CORRECTLY NOW.

C. Acceleration

As soon as you have turned and the car is pointing toward the Apex, begin to accelerate. Do not coast through the turn. How' much you can accelerate will depend on a number of things, but the general rule of thumb is that you should have the accelerator pedal down on the floor as you clip the Apex point. (Your instructor will assist you in making this determination.) DO NOT SUDDENLY LIFT YOUR FOOT OFF THE ACCELERATOR WHILE THE CAR IS TURNING. (It transfers weight and could cause the car to spin out.)

By the end of your first track session, you should be able to consistently drive the correct line (exactly) in each turn, and you should be recording a mental picture of how everything looks when you're driving the correct line, particularly, the picture of the Apex and its setting just after you've turned in. This information will be extremely important to you as you begin to drive faster. If you make a mistake in beginning your turn, the earlier you recognize your error, the easier it will be to take corrective action (slow down) to avoid a potentially serious problem later in the turn.

During this first track session, you do not need to and shouldn't drive fast. Speed will not impress your instructor. However, driving smoothly, on the correct line, using the brakes properly and accelerating at the proper time will. Drive at whatever speed (within reason) will allow you to consistently drive the correct line. Speed is not important right now. Driving the correct line is. If you cannot drive the correct line, you will not be able to drive fast. Frequently, the slow drivers in the first session are among the quickest drivers at the end of the day.

D. Downshifting

If you do not already know how to heel and toe (we will discuss this technique later), we suggest that you don't try downshifting during the first track session. Just stick the thing in third gear, and concentrate on what we have discussed so far.

If you do know how to heel and toe and can do it proficiently, the correct procedure is to finish shifting while the car is still traveling in a straight line. The clutch should be released with the transmission in the proper gear just before you turn in. The longer you wait before engaging the lower gear, the less likely will be the chance of an overrev. (i.e., spinning the engine faster than it was designed for—over the red mark on the tachometer. Damage from overreving generally occurs during downshifting.)

E. Track Layout

Memorize the track so that you will know exactly what's coming next. You cannot drive fast if the next turn comes as a surprise and you merely react to it. Know what's coming next and what you are going to do when you get there. When you work comers, study the terrain near the exit from the turn. [Is there room to go off the road there without serious consequences?] The information may come in handy before the end of the day.

Use some of your rest period time to go off by yourself and think about the track and your driving. Mentally drive the track several times—talk your way through it. The great thing about this is that you will do it perfectly every lap. During your next track session, you'll be surprised how much you've improved since the previous session.

IV. ATTITUDE

Stay alert, this is serious business, but don't tense up. Relax and drive with an air of calm. Listen to your instructor and follow his/her directions. THINK.

Class II

I. Physics of High Performance Driving
A. Friction Circle
B. Speed in a turn
C. Relationship to Performance Driving
D. Slip Angles
E. Oversteer and Understeer

II. Skid Control
A. Total Loss
B. Less than a Total Loss

III. Agricultural Driving

IV. Brake Points

V. Driving in the Rain

Class II

I. Physics of High Performance Driving

There are several physical concepts that are important to high speed driving. These concepts are interrelated and while you may find the following discussions to be somewhat dry, it is important for you to understand what is happening to your vehicle during spirited driving.

A. Friction Circle

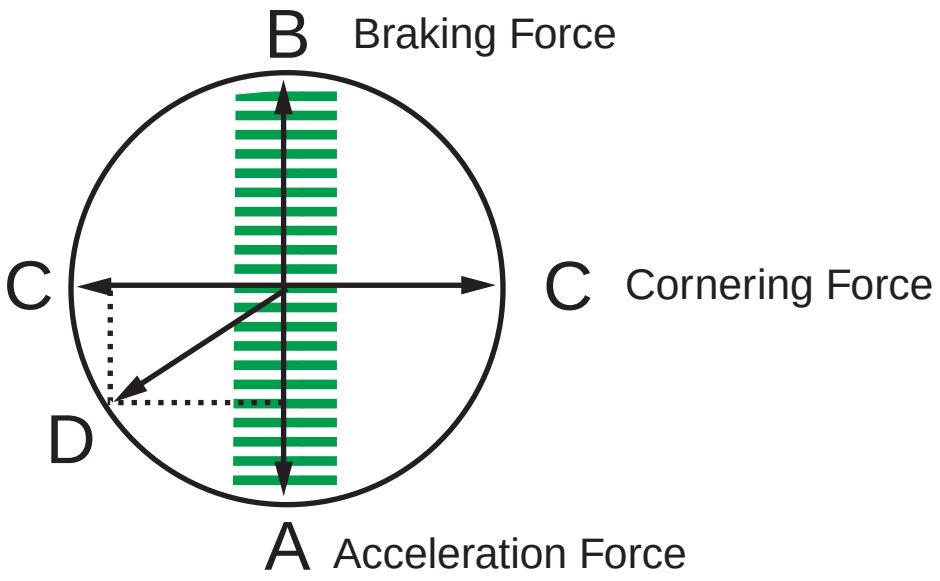
An automobile contacts the road surface through its tires (at least that is the position you should strive to maintain). A tire's contact patch is about the size of a post card, or about the size of this page for all four tires combined. The contact patch area for any given weight automobile remains constant regardless of the size of the tire. When you hear someone say that they put wider tires on their car to get more rubber on the road, they don't know what they're talking about. Wider tires will change the shape of the tire patch, making it wider but shorter and perhaps increasing cornering traction but the total area of the contact patch remains the same.

These four contact patches and their ability to grip the road surface ultimately determine the car's limits for accelerating, braking, and cornering. The tire's ability to grip the road surface depends on a number of factors including the road surface, tire compound, size and shape of the contact patch, weight on the tire, inflation pressure, age of the tire, the amount of tread on the tire, etc.

Every tire has a maximum limit of adhesion—its traction limit (taking into consideration all of the above factors). If this limit is exceeded, the tire will lose its grip on the road surface and will spin or skid.

A tire's traction limit is equal in all directions—forward, backwards, or sideways. Stated another way the traction limit is the same for braking, accelerating, or cornering.

Look at Figure 3. The thing in the center represents a tire. The circle represents the traction limit of that tire. “A” therefore is the acceleration traction limit, “B” the braking traction limit, and “C” the lateral traction limit. Note that the limit is the same in all directions.



“D” represents the traction limit of a tire being subjected to both lateral (cornering) and acceleration forces. Notice that when the tire is called upon to do more than one thing at a time, there is less traction available to turn (C) and less to accelerate (A). The total traction available, however, remains the same.

Figure 3 is a representation of the Friction Circle.

B. Speed in a Turn

The maximum speed a vehicle can attain in a turn can be expressed by the equation 15gR = (MPH). 15g is the traction limit of a particular tire on the particular road surface and R is the radius of the turn. You need not remember this equation but do remember (and you probably already instinctively know) that the larger the radius of the turn, the faster the car can travel through that turn without losing traction.

C. Great, but how does all this relate to high Performance driving?

Remember we told you to complete all of your braking while traveling in a straight line? You now know from the explanation of the “Friction circle” that braking without turning the wheels will give you maximum braking traction and that if you turned the wheel while using maximum braking traction the tires would lose all traction, you would lose control of the vehicle, and you would become merely a passenger.

“Okay, but you also told us we could begin accelerating while we’re still turning. The “Friction Circle” illustrates that we can’t do that if we’re using maximum cornering traction.”

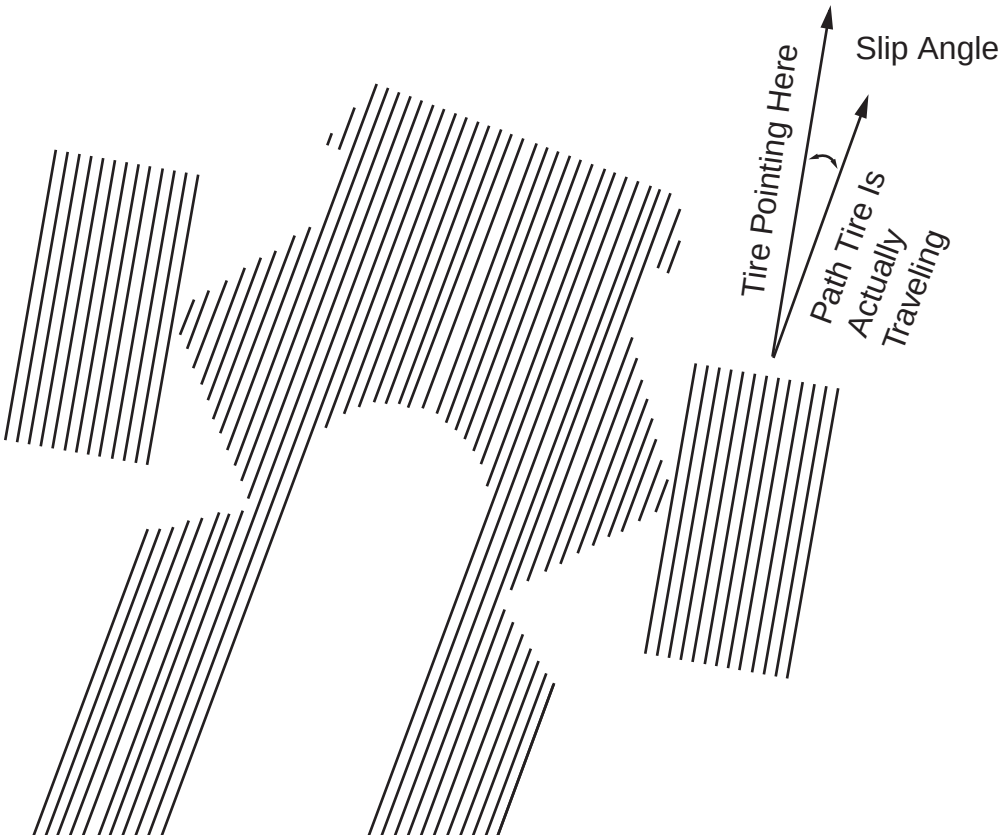
Correct, but you forgot about 15gR = (MPH)2. Look at Figure 2 again (page 8). Notice that the initial turn-in is quite sharp. At this point, we are neither braking nor accelerating. Notice also, however, that thereafter, the radius of the line increases dramatically. After the initial turn-in, we are using no where near the tires' lateral limit of adhesion because the radius is so large. We now have reserve traction for more acceleration—so let's do it.

One more point about traction (adhesion). A tire's traction limit is affected by the amount of weight on the tire. The more weight there is on a tire (downforce) the greater its traction limit. When an automobile is accelerated, weight is transferred (via the cars' suspension) to the rear tires. Therefore, when you accelerate after the initial turn-in, you are actually increasing the limit of adhesion of the rear tires. The lesson of course is don't coast through a turn.

D. Slip Angles

"How will I know when I'm approaching the limit of adhesion of my tires?" "Slip angles." "What the heck are slip angles?"

A tire is elastic. A force applied to it in any direction will distort the tire's basic shape. A cornering force distorts it sideways at the point of contact with the road. This sideways distortion makes the car follow a path at an angle to the direction the wheel is pointed. This angle is called the "Slip Angle." (See Figure 4)



The higher the cornering force on the tire the larger the slip angle.

At the instant a tire loses traction, the slip angle is zero but as long as he direction of the car can be influenced by the steering wheel, there is a slip angle. When cornering, the slip angle of a tire can range from very small (very little cornering force) to very large (very high cornering force to zero (no cornering force, the tire has lost all adhesion). Maximum cornering is achieved with slip angles of about 8°.

When the slip angle is relatively small, you may hear a faint squeal from the tires. As the slip angles become larger, the squeal will become louder. When the slip angles become zero, the tires will screech loudly and you will not be in control of the vehicle. You will be, as we say, a passenger. Loud squeals are good, loud screeches are to be avoided. (Note: Modern high performance tires don't make much noise.)

Just before screeching loudly, the slip angles become very large. The tires have lost some of their traction and are sliding sideways somewhat but they still have some traction and the tires are still exercising control over the direction the car is traveling. This condition is called "A Drift. "A Drift" through a turn is desirable.

"A Drift" is the reason you should be driving the correct line Precisely. If you turn in too soon (early "Apex") or don't get to the "Apex" you may drift right off the exit side of the turn. If you're a foot away from the "Apex," you will have a foot less roadway on the exit side of the turn. If you miss it by four feet, the exit side of the turn becomes at least four feet narrower. Take an early "Apex" and you'll have a lot less roadway on the way out. It is Very Important to Drive the Correct Line.

Understeer and Oversteer If the "Slip Angles" at the front tires are much greater than those of the rear tires, the car is said to understeer, push or plow. To the driver, it feels as if the car won't get itself turned in and the driver must continue to add steering lock (or slow down or both) to get the car pointed into the Apex. An understeering car is a safe car for an inexperienced driver because to correct it, the driver need only back off the throttle and add more steering lock in the direction he wants the car to travel. Most drivers will do this instinctively. An understeering car is, however, not a very satisfying car to drive quickly and it's generally not a quick car around a race track.

When the Slip Angles of the rear tires are greater than those of the front tires, the car is said to oversteer or to be loose. The front of the car turns in real well, in fact, it begins to describe an arc which is tighter than the driver had intended. This happens because the rear of the car is trying to get through the turn before the front of the car.

An oversteering car is more fun for the experienced driver to drive quickly than an understeering car, however it is more difficult for the inexperienced driver. Suddenly lifting off the throttle (the natural tendency) will transfer weight off the rear tires, reducing their traction, increasing the slip angles and the oversteer. This little exercise in futility is called "Trailing Throttle Oversteer" or merely TTO. TTO can be induced by lifting off the throttle while turning. This might be useful for autocrossing but don't do it on the track.

A vehicle may understeer in some turns and oversteer in others. It may also do both in the same turn. Most cars will understeer if the turn is entered at too high a speed. It may then transition to oversteer when the throttle is released. Most BMWs do not understeer (they tend to oversteer). If you detect understeer, you are entering the turn at too high a speed.

Ideally, we want a neutral handling car, one which neither oversteers nor understeers. We want to have the same slip angles at both the front and the rear so that we can drift through the turn with the rear tires following the front tires.

II. Skid Control

You, the driver must be keenly alert to what the car is doing so that you are able to detect the first signs of the rear of the car coming unglued (oversteer). The experienced driver will detect the condition very early and will merely maintain a constant throttle position (or back off the throttle slightly and very very gently) and add a small amount of opposite lock (turn the steering wheel in the direction he wants the front of the car to go). Don't' overreact. Don't attempt to correct a problem before it happens. Wait for it to happen and correct simultaneously.

A. Total Loss—If you don't try to drive over your head, this will not happen to you.

If corrective action is not taken soon enough, you will not be able to correct it. If you lose it that badly (this evaluation must also be made rather quickly), PUT BOTH FEET IN. Left foot down on the clutch, right foot down on the brakes. The car's brakes will lock and with any luck, the car will spin violently, dissipate its speed on the track surface and stop on the inside of the turn's track surface facing approximately in the originally intended direction of travel. Locking the brakes in a spin also means your car will continue in a predictable direction so a car coming up on you will know where you're headed. Releasing the brakes before you come to a complete stop allows your car to bound off in any direction without warning. If you engaged the clutch early on, the car's engine will still be running when the car comes to a halt and you can slip the gear selector into first, check for traffic and motor off like a stunt driver. It may also be a good idea to now motor into the pit area and stop there until your heart rate returns to normal.

B. Less than a Total Loss

Somewhere between catching the skid very early and losing it completely is an area where the car can still be brought under control. The dilemma: if you suddenly jump off the accelerator, you will lighten up the rear end and reduce the traction available at the rear of the car. Staying on the throttle, however, will make matters worse because you've already lost the lateral traction of the rear tires and in persisting on the throttle you're asking the tires to do two things at once (remember the Friction Circle theory).

The trade off favors backing slowly out of the accelerator, disengaging the clutch and counter-steering. "Counter-steering?"

Somewhere in our meager drivers training we have all heard about controlling a skid on ice or snow and some of us have actually done it. We were always told to turn the wheels in the direction of the skid. Some of us figured out what this meant—some of us didn't. All it means is that you turn the wheels in the direction you want the front of the car to go.

Controlling a skid at high speed on a dry surface is just like controlling a skid on ice or snow. Well, almost. If you crank the steering wheel a lot on ice or snow, the rear end will swing out of the skid and continue swinging into a skid in the opposite direction whereupon you crank the steering wheel the other way and the rear end now swings around in the opposite direction and so on and so on. All the while, the car is slowing down and the swings from side to side become smaller and smaller until eventually you gain control of the car.

If you crank the wheel a lot in the direction you want the front end to go on dry pavement at high speed, that will likely be the last time you are in control of the vehicle. That gentle counter skid you experienced on the icy street becomes a violent counter skid on dry pavement at speed. The counter skid will occur so violently and so quickly you will likely not be able to catch it. If you cranked the wheel far enough, you probably won't even know what happened.

Counter Steer Only Enough to Correct the Original Skid. Too little is preferable to too much. Don't overreact.

III. Agricultural Driving (or Off-Roading)

LISTEN UP. THIS IS IMPORTANT. Over the years, fear of agricultural driving has caused almost all the serious damage suffered by cars at club schools. The damage results from going off the track surface followed by an ill-advised attempt to quickly regain the track surface out of some belief that a motor vehicle can't be operated off the pavement.

Not true. Watch most any race, and you'll probably see cars driving off the track surface. I'm not talking about loosing control of the car on the track surface and spinning off the track. In that case, it doesn't matter what you do because, by definition, the car is not under your control, you are merely a passenger.

What I am talking about is running out of track surface while you're still exercising some control over the car. Should this happen to you, DO NOT ATTEMPT TO QUICKLY REGAIN (OR AVOID RUNNING OFF) THE PAVEMENT BY:

1. Adding more steering lock, and/or
2. Jumping off the throttle.

The combination of 1 and 2 above will generally result in a total loss of control and you will most likely spin and go off the track on the inside of the turn (when you thought you were going to go off on the outside). It will occur quite quickly.

Of course, driving around on the unpaved part of the track could involve certain hazards, and is not recommended; however, if you're in control of the vehicle when you go off the paved surface, you'll be in a better position to avoid those hazards than if you're merely a passenger.

The agricultural form of high performance driving, at least the potentially dangerous type, will occur at the exit of a turn. You're full on the throttle, past the apex, drifting toward the outside of the track, and ——- "Oh no, I'm going to run out of track on the outside". The untutored normal response? Jump off the throttle and add steering lock (i.e., turn the steering wheel more).

SUPPRESS YOUR NORMAL RESPONSE MECHANISM.
DO NOT JUMP OFF THE THROTTLE.
DO NOT ADD STEERING LOCK.

Why not?

1. You're probably not going to run off the road, it just looks and feels like you will. If, however, you now do either or both of the above, you will definitely be going off the road.

2. TTO (Trailing Throttle Oversteer).

3. If your vehicle is in a drift (which it is) it's at its limit of adhesion. If you now request more rudder, you'll loose traction (see friction circle discussion on page 14).

So what should you do?

If only the outside tires drop off the roadway, nothing much will happen. The car will probably behave just as if all four tires were on the pavement. However, don't attempt to bring those tires back on the track until you're sure the car is under your control. When you are ready to get back on the track surface, do it gradually (i.e., opposite of cranking in a lot of steering lock to get it back on the track in a hurry).

If all four wheels go off, you will experience a change in road surface that you'll need to adjust to.

THE CAR CAN BE DRIVEN ON THE GRASS, GRAVEL, OR WHAT HAVE YOU.

The potential danger lies in attempting to get back on the track too quickly. You must keep the car under your control.

DON'T JUMP OFF THE THROTTLE AND
DON'T ADD STEERING LOCK.

You may come off the throttle very gradually (breathe out of the throttle). It may also help to reduce steering lock. That is, increase the radius of the arc in order to gain or retain traction (i.e., drive farther off the road). Once you have the car slowed down, and you are fully under control, you may re-enter the track if there is no traffic in the immediate area. If you cannot see enough of the track to tell if it's clear, point at the track and wait for a comer worker to signal that it's alright to re-enter the track.

IV. Brake Points

"How close should I get to the turn before I start to brake?" I don't know. Your brake point is personal to you and your car. I can only tell you how to go about finding it.

Pick out a marker of some sort near the turn (preferably a permanent one. Don't use a lawn chair that someone may move). When you get to that point, begin threshold braking. If you come to a stop well before the turn-in point, obviously your brake point is too soon. Move your brake point closer to the turn-in point. Keep moving it until you have the desired entry speed at the turn-in point.

Remember, you want to be able to begin accelerating as soon as possible after turning in. Therefore, each time you move your brake point closer to the turn in point, note where you are able to begin acceleration. If you are unable to begin accelerating as early as you could with the previous brake point, your brake point is now too late. Move it back.

The ideal brake point is one which, using threshold braking, slows the car enough to negotiate the turn on the proper line and permits the earliest application of throttle.

Two factors may have an effect on the brake points that you establish for yourself early in the day. As your driving improves, you'll be going faster when you reach your brake point than you were earlier. You may find that your brake point is too late. On the other hand, as your driving improves, you may be able to handle higher cornering speeds. You may find that your earlier brake points are too early. JUST KEEP THIS IN MIND.

You should also keep in mind that the track surface will have an effect on braking: New asphalt—generally slippery Gravel or dirt Oil or coolant Braking going downhill

All increase braking distances—BE ALERT FOR THESE CONDITIONS.

Very few things decrease braking distances. Braking going uphill is one. Hitting the car in front of you is another. WATCH YOUR INTERVAL.

"What if I can't get slowed down enough to make the turn?" Then don't make the turn, but congratulations on recognizing that you're going too fast. The general rule is if you're going too fast to turn in, don't. Continue threshold braking and drive straight off the turn. You will be able to steer the car when it leaves the track and you will hopefully be able to bring it to a stop before coming into contact with something hard or, at least you might be able to steer around the hard object.

If you're going too fast to make the turn and turn anyway, you're still going to go off the track but you won't be in control of the car. You will be unable to steer, brake, or exercise any control whatsoever over the car.

The exception to the rule of course is when the consequences of driving straight off the track are potentially worse than spinning off of it. For example, a concrete wall on the outside of the turn—very unforgiving.

V. Driving in the Rain

Driving on wet surfaces requires smoothness to the Nth. degree. Your vehicle will have considerably less acceleration and braking traction and a whole bunch less cornering traction. On a wet surface, you will have only about 70 percent of dry acceleration traction, about 50 percent of dry braking traction, and a mere 20 percent of dry cornering traction. It should be clear to you from this that a wet surface requires a considerable reduction of speed. If the surface is extremely slippery, coast through the turns and don't apply throttle until the car is traveling in a straight line.

At most race tracks, you may find that the Line becomes extremely slippery. Cars running on the track deposit rubber from their tires on the Line. In addition, if a car leaks any fluids, it will generally be deposited on the line. When it rains, the oil and rubber float to the surface and ride on top of the water. If the line becomes unreasonably slippery, try avoiding the line. Drive around the outside edges of the turns. This part of the turn is seldom used and you'll find that you have reasonably good traction there. Beware, however, that even if you drive the outside edges of the turns, you will still be braking on the same slippery line and at some point in the turn you will again meet and cross the Line. You may go from reasonable traction to "Oh my God."

Driving in the rain (or on ice or snow) is great for working on your smoothness.

CLASS III

I. Down Shifting
A. Heel-Toe
B. Double Clutching

II. Trail Braking

III. Line-Detailed Discussion
A. Largest Possible Radius
B. Late Apex
C. Early Apex
D. Finding the Correct Line
E. Entry Speed

I. Down Shifting

A shift down to a lower gear is done to obtain the gear that will permit the maximum acceleration out of the turn. IT SHOULD NOT BE DONE TO SLOW THE CAR.

Shifting, like braking is completed while the car is traveling in a straight line. If you are threshold braking and simultaneously shift to a lower gear, the engine's RPMs will drop to idle speed. When the clutch pedal is released, the car will jerk (caused by the rear wheels stopping momentarily). This is the equivalent of suddenly adding more braking to the rear wheels. This may cause a loss of traction at the rear tires and will definitely transfer weight fore and aft, upsetting the car's balance just before it enters the turn. It is unsmooth.

A. Heel-Toe

To avoid upsetting the car's balance, we must raise the engine's RPMs just before releasing the clutch pedal.

Since most of us have only two feet and the car has three pedals to operate the brake, clutch, and throttle, one foot must do double duty. Your right foot must operate the brake and. at the same time. blip the throttle.

The easiest way to do this is to place the ball of your right foot on the right side of the brake pedal. Twist your right leg around slightly so that your knee is pointing slightly inward. Now you can operate the brake and when you need to blip the throttle, roll your foot to the right and contact the throttle with the right side of your right foot This is done without releasing the pressure on the brake pedal.

If your foot is too small or your car's pedals are too far apart, you can blip the throttle with the heel of your right foot while maintaining brake pedal pressure with the ball of your foot.

This is known as heel and toe. The correct procedure is as follows:

1. Threshold braking (continue braking through 2, 3, 4, 5, and 6 below).

2. Depress the clutch pedal.

3. Move the gear selector to neutral—pause momentarily in neutral and then,

4. Move the gear selector to the gear you want to use.

5. Blip the throttle (make sure that you then fully remove your foot from the throttle).

6. As the RPMs begin to come down, release the clutch pedal. Don't release the clutch until the RPMs begin to come down, but release it before the engine returns to idle RPMs.

With practice, you'll learn just how much to blip the throttle and the proper RPM at which to release the clutch. If you've blipped the throttle too much (or let the clutch out too soon), the car will lunge forward (under acceleration). If the RPMs are too low (or you release the clutch too late), the rear wheels will grab—it will feel like additional braking. If you do it correctly, the car's attitude will not change and except for the change in the sound of the engine the gear change will not be perceptible.

Caution—Heel and toeing takes practice. While you are learning to do it, braking distances will increase.

B. Double Clutching

Double Clutching is employed to minimize wear and tear on the vehicle's drive train. It is used along with heel and toeing. If you want to become a really accomplished driver, you should learn to double clutch, but it is not essential to high performance driving. Heel and toe shifting IS ESSENTIAL to becoming a high performance driver.

The correct procedure for double clutching:

1. Threshold braking (which continues through Steps 2 through 8).

2. Depress the clutch pedal.

3. Move the gear selector to neutral.

4. Release the clutch pedal.

5. Blip the throttle.

6. Depress the clutch.

7. Move the gear selector from neutral to the gear you want.

8. Release the clutch pedal.

Be extremely gentle with the gear shift lever, it's connected to some delicate and expensive parts. There is no need to slam the gear lever into any gear—be gentle.

II. Trail Braking

During this school, we've stressed that all braking must be completed while your vehicle is traveling in a straight line. There is, however, another theory ascribed to by some experts (an expert is anyone who has more experience than you). The theory is that to be fast, the driver must trail the brakes into the turn. Those who advocate Trail Braking include Skip Barber and Bob Bondurant, among others.

Former World Champion Jackie Stewart, among others holds to the view that braking should be completed before turning in. Mr. Stewart, when asked about trail braking as advocated by Barber, Bondurant, et al., responded with a question of his own, "How many world championships have they won?"

I don't know who is correct, however, I think a very good driver should know how to do both. I have found that trail braking works very well in some turns in all cars and perhaps for all corners in some cars.

Here's how it works. Threshold braking is used just as we've instructed. Just as you reach the turn-in point, however, the brakes are not fully released but are continued slightly as the car is turned in. If you use too much brake, the car may spin.

To get the proper amount of braking, imagine a left turn and that your hands on the wheel and your foot on the brake pedal are connected by a solid rod. In order to turn the wheel, you must also raise your foot off the brake pedal. The more you turn the wheel, the more your foot must raise off the brake pedal.

Trailing the brake will keep more of the vehicle's weight on the front tires, yielding more traction there and the car will turn in very well. The rear tires, however, will have less weight and therefore less traction. As the vehicle is turned in, the rear of the vehicle will begin to slowly come around (rotate toward the outside of the turn) and point the front-end toward the Apex. As soon as the car is pointed toward the Apex, the throttle is squeezed on, transferring weight (and traction) to the rear tires. The rear tires will gain traction, stop sliding and the car will accelerate toward the Apex. If throttle is not applied at the proper instant, the rear may continue to slide which may result in a spin.

For corners that trail braking works well on, it works very, very well.

CAUTION, the transitions between threshold braking, trailing the brakes, turning in and application of throttle must be performed extremely smoothly. In addition, when trail braking is used, the steering wheel is turned less than it would be turned without trail braking. Without trail braking, only the front steering is used to get the car turned into the Apex. When trail braking is used, however, the rear end rotating out has the effect of adding some steering.

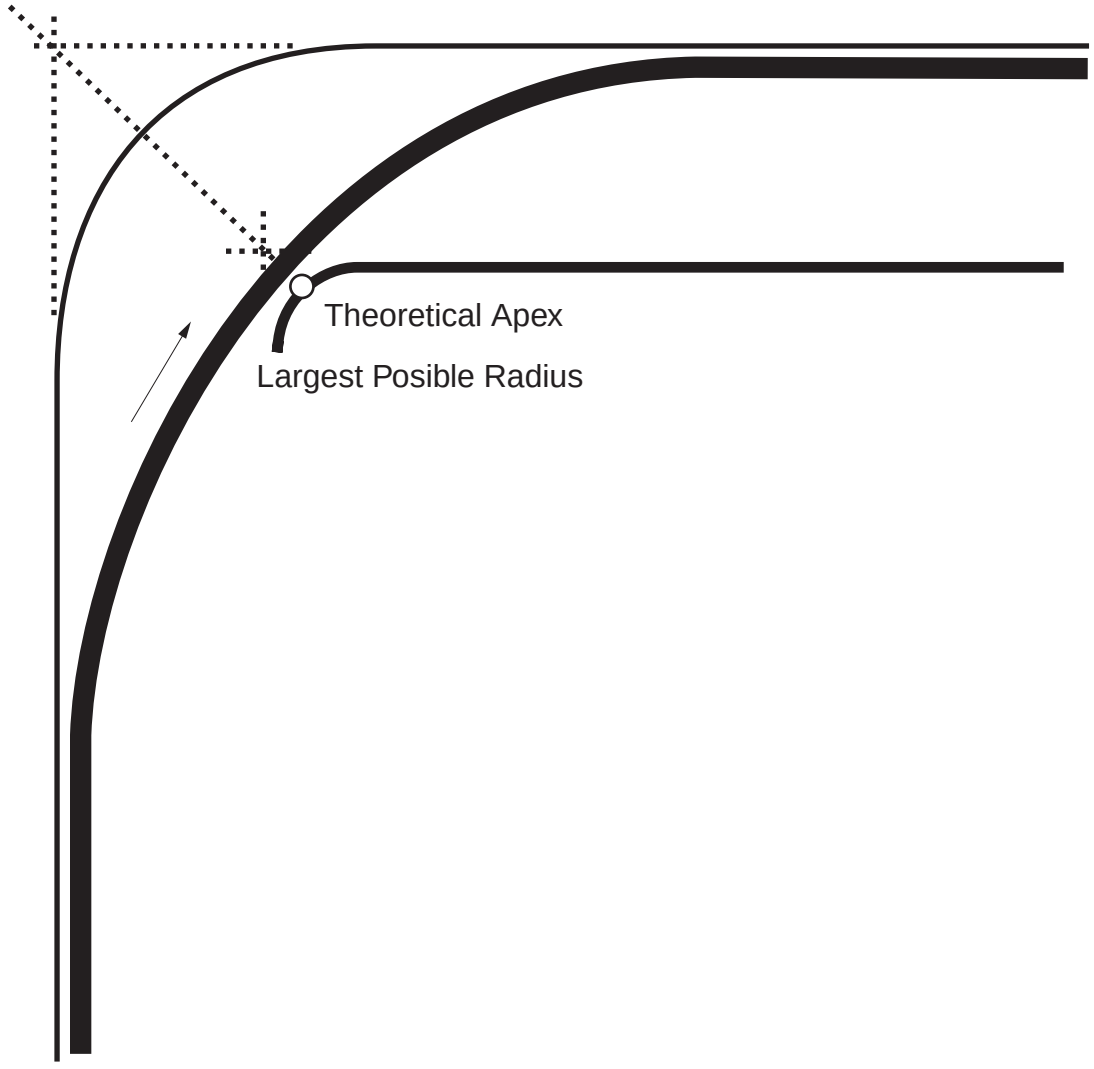
We recommend that novices do not attempt trail braking. If you want to learn it, wait until you have more high performance driving experience or go to Skip Barber's school and learn trail braking in his cars.

III. Line—Detailed Discussion

An Apex is an imaginary point at the edge of the roadway on the inside of a turn that the car touches as it travels through a turn.

A. Theoretical Apex & Largest Possible Radius

An Apex at the geometric center of a turn's arc is called the Theoretical Apex. If a vehicle is driven from the extreme outside edge of the roadway, then touches the Theoretical Apex and then touches the extreme outside edge of the roadway, the vehicle will have described a line through the turn which will be the largest possible radius through that turn (Figure 5, page 29).



We know from our equation 15grr= (mph)2 that the larger the radius of a turn, the faster a car can travel through that turn. The largest possible radius is the fastest way to go around a turn. It is generally not, however, the fastest way around a race course. If we were to add up the time spent on turns and the time

spent on the straights on one lap of the track, we would find that we spend considerably more time on the straights than in the turns. We can go very fast on the straights but not so fast in the turns.

The largest possible radius would be the line to use if our course consisted only of corners that could be driven at our car's top speed (and it is the line to use when negotiating such a turn). In reality, most corners on a track cannot be negotiated at our car's top speed. We must reduce our straight away speed (by using the brakes) in order to go around the corner. If, however, after braking and turning into the Apex, we could begin to accelerate before the car was totally finished turning,

we would, in effect, be making the following straight longer. If the straights were longer, our terminal speed at the end of the straight would be higher. It follows that if we go faster on the parts of the track where we spend most of our time, we will get around the whole course in less time.

Recall our friction circle. If we are driving the largest possible radius as fast as physically possible (at the tire's limit of adhesion), we cannot accelerate until the car is once again traveling in a straight line. So, what do we do? Use a Late Apex line.

B. Late Apex Line

A late Apex line is the line described by a vehicle which touches an Apex occurring after (later than) the Theoretical Apex. This is the line you have (should have?) been driving all day and the line you should use all of the time on a race track OR ON THE STREET (unless you have a good reason for doing otherwise. Brain fade is not a good reason.)

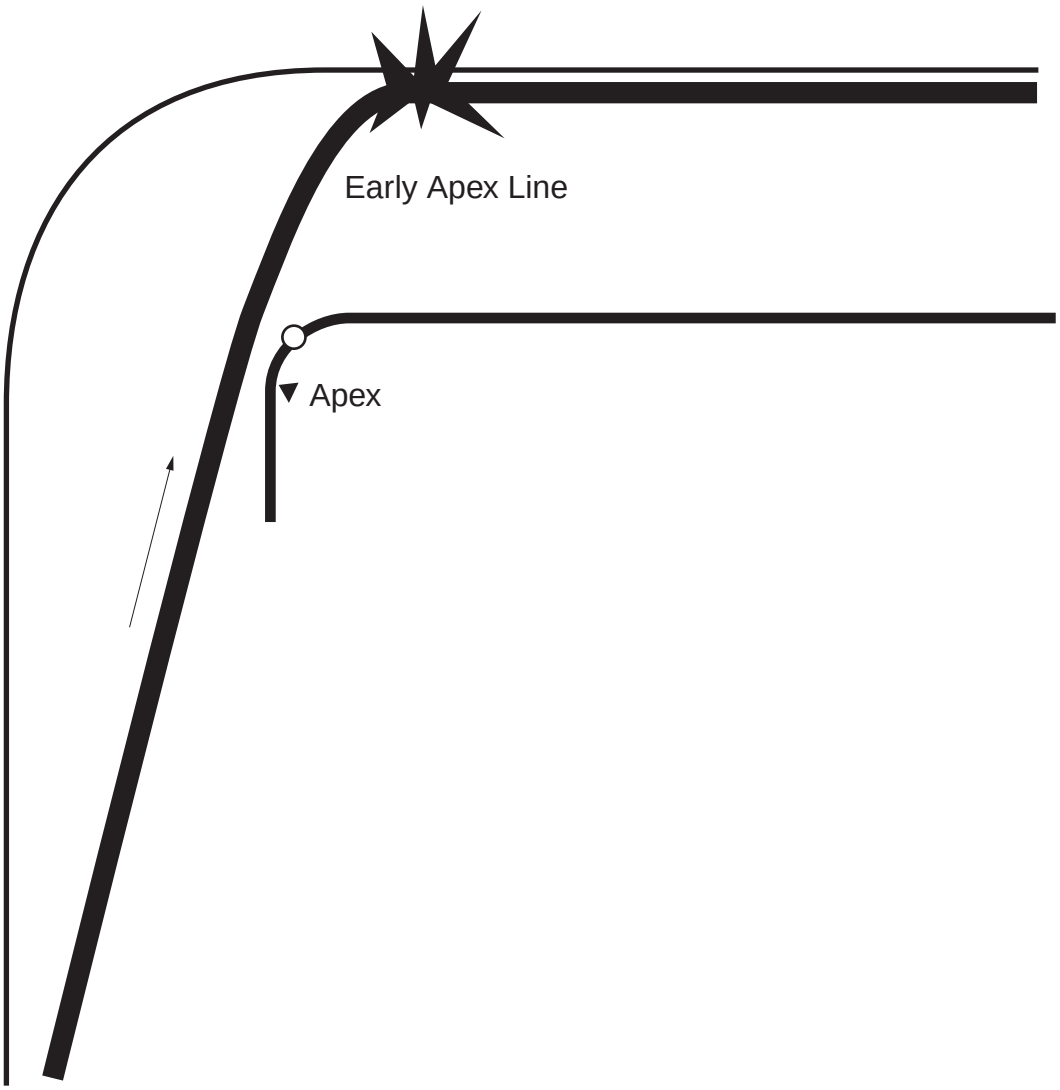
Why it's the Fastest

Look again at figure 2 (page 8). It illustrates a late Apex. Note that the beginning of the turn is much sharper than it would be if the largest possible radius were used. Because of that initial sharp turn, we will need to slow down more than if we used the largest possible radius. (Remember our friction circle.) Notice also, however, that after that sharper turn, the balance of the line has a much larger radius than even the largest possible radius. Therefore, we can, and should begin to accelerate almost immediately after making that sharp turn. How much you can accelerate will depend on a number of factors, the radius of the turn, whether the roadway is banked, flat or off-camber (the opposite of banked), the power of the car, whether or not you wish to induce oversteer, etc. The rule of thumb, however, is that steady throttle is used to the Apex (to maintain the maximum cornering speed for the given radius) and full throttle at the Apex (as the radius increases); your instructor will help you on this point.

Assuming that you have driven the correct line, have not entered the turn too fast, and the road is not slippery, you should never coast through a turn. Always apply power after the car is turned toward the Apex. This application of throttle transfers weight to the rear tires, increasing their traction for acceleration.

C. Early Apex

Look at Figure 6. It illustrates an Early Apex Line. (The Apex occurs before the Theoretical Apex).



If you take this line, you will not only be a “sleaze ball early apexer,” but if you persist with full throttle at the Apex, you will fall off the roadway, the car will likely then accelerate sideways, you will become a passenger Instead of the driver and you will not like it, or worse. If you use an early apex line in your street driving you will run the risk of a head-on collision with any car traveling in the opposite direction because your car will be in the wrong lane.

Notice that with an Early Apex, the sharpest part of the turn occurs after the Apex. It cannot be negotiated at the same speed as the early part of the turn. It requires slowing down before the sharp part of the turn.

The most common error made by drivers is turning in too soon resulting in an Early Apex Line. Most likely, you will also make this mistake, and your Instructor will scold you. If you persist in this ail day long, you will be known as a SLEAZE BALL EARLY APEXER.

The Early Apex Line is not totally without socially redeeming value. It might be the best line to take if a long straight is followed by a very slow section of track, say several slow turns in quick succession where the only line you're concerned with is the line through the last turn in the succession of turns. A Late Apex in this situation permits you to carry your straight away speed longer. You would threshold brake up to the turn-in point, but because the early part of the turn has a relatively large radius, you could continue some braking all the way to the point where the radius becomes smaller.

If you're thinking, you have probably already figured out that it might also be useful if you're approaching a turn too fast and can't get slowed down enough to take the proper line The Early Apex Line will give you more braking distance to work with. You can forget about a good lap time, but it might prevent an off road excursion. When you are traveling on an unfamiliar road, NEVER, NEVER Apex early. In fact, don't even think of apexing until you can see where the road is going. Stay out wide until you can see what's on the other side, then apex.

D. Finding the Correct Line

Start by using a very late Apex (usually later than you think it is). If the Apex is too early, you will find that you are unable to unwind the steering wheel as you clip the Apex (falling off the road is also a clue). If you can't get to your Apex, it means that you turned in too late.

Once you have found an Apex and a turn-in point that works reasonably well, start refining it. What you want is exit speed. Exit speed translates into RPMs which translates into speed at the end of the following straight. Pick out a spot or convenient mark on the straight some distance after the corner. The distance doesn't matter as long as you use the same mark every time.

Each time you pass your marker, check the RPMs and note whether or not you've used up all the roadway on the exit side. If you still have some room on the exit side, try a slightly earlier Apex and check the RPMs at your marker. Are your RPMs higher or lower? Keep experimenting until you find the line that consistently yields the highest RPMs at your marker.

This exercise can also be used to determine the correct gear for a particular turn.

Don't trust the seat of your pants. Lots of noise and wheel spin does not generally equate with the fastest way through the turn. Note, your

marker must be far enough down the straight so that regardless of the gear used for the turn, you are always in the same gear when you pass your marker. The gear that results in the highest RPMs at your marker is the gear to use for that turn.

You will frequently find that you can use a higher gear than you originally thought.

E. Entry Speed

The speed at which you should enter a turn is more or less a seat of the pants proposition. The tendency is to go too fast in slow corners and too slow in fast corners. We recommend that, at first, you concentrate on

exit speed. Go in slower that you think you need to so that you can get full throttle at the Apex. As you become more experienced, you can begin to pick up your entry speed. Remember, the underlying principle is to accelerate as soon as possible so that you go faster on the straights. If you enter too fast, you won't get to your Apex and you'll be fighting to control the car at the point where you should be accelerating.

In high performance driving, no one is a natural, everyone must learn. Those who concentrate on smoothness ~g consistency learn faster. Those who think charging down the track is the answer, braking at different spots each time, reacting rather than anticipating, learn nothing.

No matter how long you've been driving on the street, or how fast your car is, or how expensive your tires are, until you are willing to rethink any driving habit—you aren't ready to learn to be a truly fast driver. You have the opportunity to vastly improve your driving skills, and with an open mind, and a lot of concentration, you'll do it. Go for it.

