Road Course

Techniques

DRIVER PREPARATION:

Just as important as car preparation is driver preparation.

First of all, relax and get ready to enjoy yourself. This school is intended to bolster confidence, not get you all up tight.

Do, however, make it easy on yourself by taking a few precautionary measures.

Don't wear thick heeled or soled shoes, they are insensitive. Wear thin soled shoes or tennis shoes or specially made driving shoes.

Don't wear loose, floppy clothes or wide flared slacks that might get caught at the wrong time. (Wear something comfortable rather than fashionable.)

Take off loose necklaces, bracelets and watches.

Bring a pair of sunglasses

If your steering wheel is not leather or rubber covered, wear a thin pair of leather driving gloves. Perspiration and moisture make a wheel very slippery.

Helmets are required. Make sure your helmet meets the safety requirements for autocross or driver's education. Please see the latest tech sheet.

Your car owner's manual may come in handy, bring it along.

Most important of all, be willing to forget any bad habits you may have acquired.

SEATING POSITION:

Nothing is more important than the correct seating position. We must convert the driver from a piece of freight to a constituent, integral part of the car. The driver, in order to control a car, must react to certain signals received from the car. This feedback of vehicle behavior is transmitted in many ways: Through the steering wheel, brake pedal, the seat, and by sight and sound. It is important that the driver be sensitive to these signals.

Most drivers sit too close to the wheel because they think they can see better. This restricts the arms' freedom of movement, because the hands must be held too high on the wheel and the elbows touch the seat back. The thighs lack support and the knees interfere with the wheel when shifting.

Most Porsche drivers, on the other hand, sit too far from the wheel, probably emulating the classic straight arm driving position. This, however, frequently causes the driver to lean forward out of the seat back in order to turn sharply or to shift. This causes a tendency to use the wheel as a brace during hard cornering, introducing unwanted steering movements.

The body is constantly displaced sideways on cornering, forward on braking and upward over bumps. No matter what happens, it is essential that the driver remain firmly in the seat.

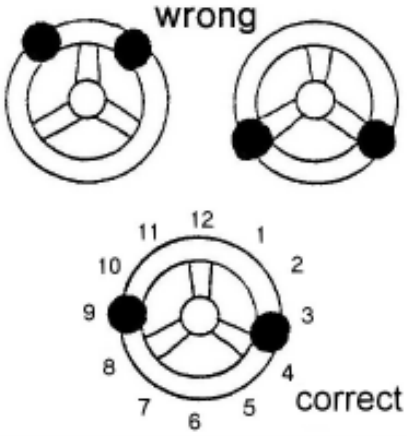
The correct seating procedure is as follows:

1. Dig yourself into the seat back by pushing with your feet. Don't sit on the seat, sit IN the seat, and become part of it.
2. Adjust the distance of the seat from the wheel so that you can reach its most distant point (i.e. left hand nine o'clock, right hand three o'clock) without leaning forward (breaking contact between the seat and shoulders). Your arms should be slightly bent.

3. Check your reach to the shift lever. Again, don't lean forward.
4. Check your feet. You should be able to push the pedals down firmly without leaning forward and your knees should not interfere with the steering wheel.
5. Adjust the seat back angle, and/or seat distance if necessary so that all of the above are achievable.
6. Tighten the seat belt as tight as you can without cutting off circulation or causing discomfort. Shoulder harness, if you have them, help provide the lateral support necessary. Seat belts are very important because they keep you in the seat, behind the wheel, ready to control the car instead of being controlled by the car. **Seat belts must be worn at all times.**

STEERING WHEEL

Holding the steering wheel is just like catching a baseball. One hand for bush leaguers and two hands for the pros. The hands are held in the nine and three o'clock position. If the steering wheel allows, hook the thumbs over a spoke. This allows you to know your exact hand position without looking.

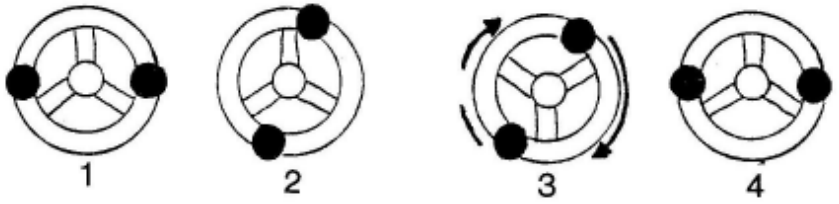


The wheel should never be gripped tightly. Your fingers should curl around the wheel lightly, the same way your fingers hold the shaft of a golf club. Don't hold the wheel with the palm of the hand, it is less sensitive than the fingers.

Holding the wheel with the fingers allows quick, precise, delicate steering corrections to be made using the wrists without moving the arms.

Any change in steering wheel rotation is called lock: i.e., left lock or right lock. It does not necessarily mean turning the wheel as far as it will go. From a correct hand position, the wheel can be turned almost a full half turn without moving the hands or crossing arms. This is adequate in a Porsche for most corners.

If, however, a sharp turn is expected, the hands should be moved on the rim before the corner. This allows the wheel to be turned over a larger arc than normal and still keep the hands in a near normal position.



If a very sharp turn (hairpin) makes it necessary to move the hands on the wheel during the turn, always turn the wheel over the largest possible arc in one single continuous stroke.

Avoid crossing the arms in a corner because a steering correction called for more lock cannot be accomplished, the arms are as far as they will go. One exception is a hairpin when the wheel is already turned as far as it will go.

When approaching a corner, the wheel is turned sharply but smoothly. Exiting the corner calls for deliberately turning the wheel back to normal position. **Do not let go of the wheel at any time**, since this leads to a time loss and the car becomes momentarily unstable.

PEDALS:

There are four pedals in your car, which you need to know about. From the right they are:

The ACCELERATOR PEDAL is quite familiar to all drivers and needs little discussion at this point.

The BRAKE PEDAL is by far the most important and sensitive pedal in the car. Much more about it later.

The CLUTCH PEDAL is used to disengage the clutch while shifting. You should know exactly at what point the clutch grabs and develop a precise touch. Riding the clutch is a definite no-no.

The DEAD PEDAL or brace pedal is positioned at the far left side and is used to provide the driver with lateral support while cornering. If you do not have one, make one, it is a good place for your left foot and will keep you from riding the clutch.

All of the pedals must be easily and quickly reached without interference from loose carpeting, steering column, wires, etc. The pedals should be covered with a non-slip material for obvious reasons.

SHIFT LEVER

The shift lever must be treated as if it were made of thin glass. Although the big plastic knob and stick shaft look sturdy, they are connected to delicate, breakable internal parts of the transmission.

Speed shifting or slamming the shift lever home is a foolish bit of exhibitionism and a waste of time. The shift lever is not held in the hand, rather it is cupped in the palm of the hand. The lever is used smoothly, delicately, precisely and slowly. If it is not going into gear or if it is grinding a gear, there is a reason. Don't force it. Be sure the clutch pedal is all the way in and the engine revs are right. With practice and a light touch, shifts will come very quickly and effortlessly. If you are grinding trying to get into 1st or reverse, try shifting into 4th or 5th with the clutch pedal fully depressed and then sequentially move the lever down through the gears. When you are not actually shifting, keep your hand off the shift lever.

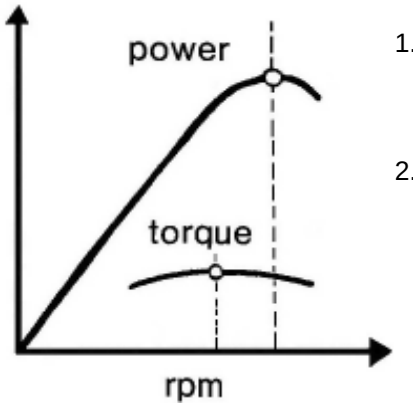
ACCELERATION

In Driver's Education or Club Racing most starts occur in a running lap after a warm up. However an Autocross starts from a dead stop and time lost at the start is never made up. A timed run requires the best possible initial acceleration. There is a procedure for drag race starts or maximum acceleration. You should remember, however, that maximum acceleration starts put a great strain on the clutch, transmission, transaxle and tires. We recommend that you learn how to do a drag start, practice it here, and then save it for when it is necessary.

When we are accelerating, braking or concerning, there is a limit as to how fast we may go. This is called the traction limit and is determined by the car's weight and tire contact patch. More about this later. Right now you should know that maximum traction for a given weight occurs when there is 15% to 20% wheel spin. That is, the wheels are turning slightly faster than they would ordinarily leaving a faint gray line on the road. You can hear a faint squeal. If wheel spin is excessive, the tires will screech loudly and leave a dark black rubber streak. This is not recommended.

If you have a very powerful car, or very skinny tires, all you need to do is step on the gas and try not to spin the wheels excessively.

If you have a Porsche, then it could be another matter. Porsches except perhaps for the turbo or race models do not waste anything, certainly not power and it becomes difficult to get the correct wheel spin without correct steps:



1. First we will need our owners' manual. Turn to the page that shows the engine power curve.

2. Make a note of the RPM at which the engine produces its maximum torque. Also note that the horsepower and torque values change as the RPM's change but not at the same rate. More about this later.

3. Now our procedure is simple. Immediately before the flag falls, wind the engine to just slightly above the RPM which corresponds with maximum torque and hold it there.

4. Now let the clutch pedal out slowly until you can feel the clutch just beginning to grab. Adjust the RPM's to maximize torque, while the car begins to move forward. Your wheels should be spinning slightly and you should hear a faint squeal form the tires. You may have to slip the clutch slightly so that you do not lose engine RPM's. Do not let the engine bog down. Do not permit excessive clutch slippage, very high RPM's, or excessive wheel spin.

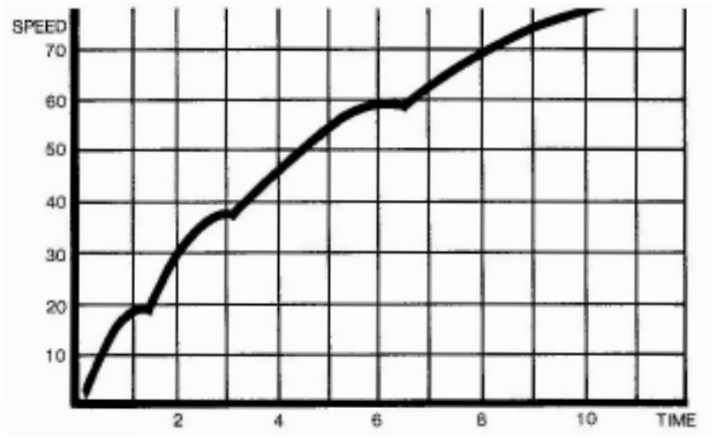
5. The clutch should be engaged all the way, before 2/3 of the RPM limit is reached. Accelerate at full throttle up to the rev limit.

6. Most cars are designed so that maximum acceleration is obtained by winding out first gear to the red line. A word of caution. In a low gear, the engine winds to red line very quickly and it is easy to overrev the engine. You should try to upshift at 500 revs before red line. By the time you react, the engine will be at red line. Over reving an engine is the easiest way to break your toy.

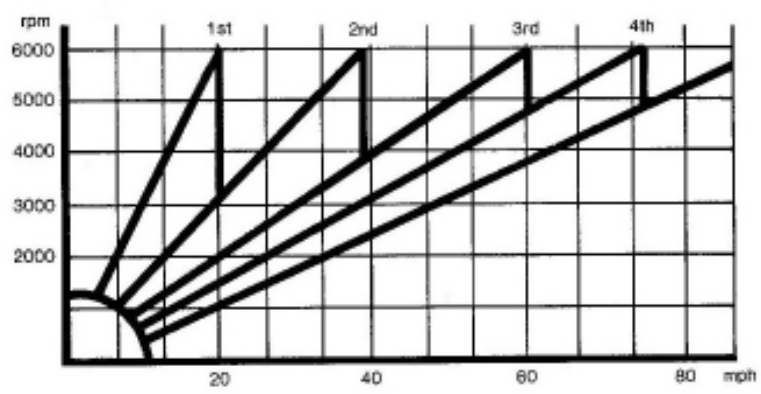
7. Cars with powerful engines that produce lots of torque do not require slipping the clutch. Also an engine whose maximum torque is in the lower RPM ranges should not be reved to red line.

Now the problem of acceleration begins to get a little tricky. Some people feel that each gear should be reved to red line. In some cars, notably race cars, that is true. But for most, it is quite wrong. The problem of when to shift as we go up through the gears is compounded by factors such as horsepower and torque curves, gear ratios for each gear, ring/pinion ratio and tire radius. Change any one and you have a new shift point. To determine the exact shift point requires a complex set of calculations and some tricky graphs.

Fortunately, Porsche has done the work for us and put it in our owners' manual. Turn to the acceleration curve graph. It shows the speed attained in each gear. Make a note of the speed for each gear.



Now turn to the transmission chart for your car. For a given gear, knowing the maximum speed, we can find the corresponding RPM. These now become our shift points. Memorize the shift point for each gear.



After completing an upshift, you will see that the engine RPM's have dropped. By referring to the transmission chart, you can determine how far the revs will drop. Draw a vertical line from your 1st gear shift point to where it intersects 2nd gear. The indicated RPM for 2nd gear is the RPM to which the engine should be brought during a shift before re-engaging the clutch.

BRAKING

Most people think of engines when you mention power. The fact is that the most powerful part of your car is not the engine, but the brakes. In fact, the brakes are more than twice as powerful as the engine. Yet, most people use only about 20% to 30% of brake capacity and even then frequently incorrectly. The easiest way to turn faster times is to use the brakes to maximum capacity.

As mentioned earlier, there is a limit as to how hard we can brake called the traction limit. This is achieved when we have 15 to 20% wheel spin. The same is true in braking. Maximum braking occurs when the wheels are turning slightly slower than they should be for a given speed.

A locked wheel while braking is a no-no. It is losing traction and braking efficiency, and cannot be steered resulting in a skid and loss of control. Anti-lock brakes on current models automatically prevent wheel lockup.

Types of braking include:

PUMPING BRAKES – is a term misused and commonly misunderstood. It does not reduce stopping distances, rather it lengthens them. Actually it provides no stopping power at all. It is a gentle pulsation on the brake pedal to build up pedal pressure due to low brake fluid pressure.

JABBING BRAKES – is what most people do when they think they are pumping the brakes. Sudden repeated brake pedal actuations, which alternately skid the tires and reduce stopping power.

ENGINE BRAKING – or lifting off the gas uses the engine to provide resistance to slow the car down. It does not stop the car any faster but is sometimes used at very high speeds in endurance races to save the brakes. It is not a very precise way to slow a car.

HARD BRAKING – to achieve maximum braking, the brakes must be applied hard enough for the wheels to be just to the point of locking up without really locking up. If a wheel does lock, release the pedal pressure slightly and then re-apply pressure. With anti-lock brakes you apply the brakes fully and let the anti-lock function modulate the brake pressure.

Very important, do not slam on the brakes. Sudden hard braking transfers weight to the front wheels putting all the braking effort on the front brakes. It also throws the car out of balance and is to be avoided.

The correct braking procedure is as follows:

1. Press the brake pedal lightly to confirm they are operational.
2. Continue applying increasing pressure. Press the brake pedal very firmly. Power assisted brakes may require less force than those without power assist, however you do want to brake hard over a short duration. Do not brake lightly over a long period, this will cause excessive heat in the brakes and may cause premature brake failure.
3. The brake pedal should be hard and firm and you should feel slight pulsations through the pedal. Develop a sensitive brake touch so that you can apply the brakes hard, yet not lock them.

CADENCE BRAKING – or intermittent braking is frequently useful particularly if braking from very high speeds, or on surfaces of questionable traction. This consists of applying the brakes quite hard, releasing the pedal slightly and then again alternately repeating the procedure.

The main thing to remember is that in performance driving, if the brakes are required then use them hard over as brief a distance as possible.

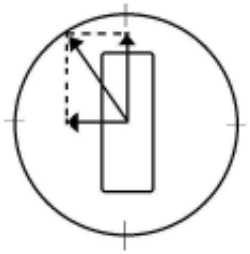
TIRE ADHESION

No matter how powerful the engine, how large the brakes, or how well the suspension is set up, there is a definite limit as to how fast we can go, stop or corner. We are limited by our tires.

The only part of the tire that really matters is the part that actually touches the ground. This area is called the tire contact patch. The contact patch for most street cars is about 80 sq. in. or about the size of this sheet of paper for all four wheels combined. It is easy to see how important it is to keep all four tires flat on the ground. If a wheel tilts or leans just slightly during a corner, we have reduced the size of the tire contact patch. The purpose of sophisticated, independent suspension is to keep the tires flat on the ground and minimize the loss of contact area.

The traction that a tire has on any given surface is determined by the size of the tire contact patch and the weight or downward force placed on the tire.

The maximum traction that a tire has is called the traction limit. The traction limit is the same in all directions. This means that we will have to exert the same force to pull a locked wheel forward, backward or sideways. Regardless of which direction we apply forces, we cannot exceed the total amount represented by the radius of the circle. It also means that when we place a combination of loads on a tire while braking on a curve or accelerating on a curve, we are using up more of the total available traction.



If we apply a force, which is greater than the radius of the circle, the tire will slide.

This explains why a car cornering smoothly near the limit on a slippery road using a steady throttle will skid if the throttle is increased or if the car is braked.

A few additional points to remember. Maximum tire traction occurs when there is approximately 15% wheel spin. If wheel spin is increased, the car loses some traction. The same holds true for braking. If the weight or downward force on a tire is increased, the traction limit is increased. Conversely, if the weight or downward force on a tire is decreased, the traction limit is decreased.

Because of tire tread design, there are some significant differences in the traction limit when surface conditions change as on wet or slippery roads.

Consider these:

	Dry Road	Wet Road
Accelerating	1.0 g	.7 g
Braking	1.0 g	.5 g
Cornering	1.0 g	.2 g

Needless to say, performance driving requires paying careful attention to road conditions and how these conditions are affecting the car's traction limits.

SLIPPING AND SLIDING

If a wheel and tire are allowed to roll without any side forces acting on them, they will roll in a straight line. Any side force applied, such as centrifugal force, will deflect the tire in the direction of the force. If a total force does not exceed the traction limit, it is called a slip. If it does exceed the traction limit, it is called a slide. More about slides later.

Even at a comparatively low speed, the tires on a car rounding a corner will not follow the path in which they are pointed. The difference between the path a tire follows and the direction a tire is pointed is called the slip angle. The rear wheels have a slip angle as well as the front ones.

For a given tire, the slip angle is dependent upon four factors:

1. The side force acting on the wheel. A tighter corner will increase the slip angle.
2. An increase in tire pressure will reduce the slip angle while a reduction in tire pressure will increase the slip angle.
3. The slip angle is reduced as weight is increased.
4. Any camber or tilt of the wheel during cornering increases the slip angle.

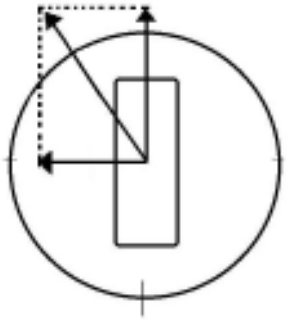
A car is said to have good road holding qualities when it has **low** or **small slip angles.**

Any increase or decrease of the slip angle will modify the path followed by the vehicle. The result is oversteer or understeer. More about this later.

SLIPPING AND SLIDING (Continued)

A slip angle reaches a maximum when the side or cornering force approaches the tire's adhesion limit. At the point you can hear a faint squeal of protest coming from the tire.

When the adhesion limit is exceeded, the slip is turned into a slide and the tire scrubs the road sideways with a loud screech.

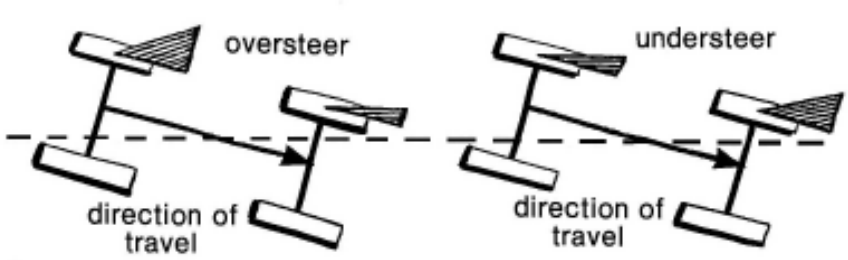


UNDERSTEER AND OVERSTEER

As we indicated earlier, any increase or decrease of the slip angles will modify the path followed by the car.

When the slip angle of the front wheels is smaller than the slip angle of the rear wheels, the car is said to oversteer and the car makes a tighter turn than usual.

When the slip angle of the front wheels is larger than the slip angle of the rear wheels, the car is said to understeer or takes a wider turn than usual.



UNDERSTEER AND OVERSTEER (Continued)

Equal slip angles front and rear will result in a theoretically neutral steering car. In practice, a so-called neutral steering car actually follows the line of a car which understeers slightly. As we will see, the perfectly neutral steering car does exist but only if it is standing still.

It is important to know that a vehicle can maintain the status of over or under steer only over a certain speed range. Thus, a car that understeers in a slow curve will oversteer if the curve is taken faster, or might understeer entering a curve and oversteer while exiting at higher speeds.

However, the sharper the turn the less oversteer will be noticed and the more understeer will become apparent. This is why oversteering cars tend to be exceptional autocross and gymkhana cars. Cars with slight understeer tend toward high speed stability and can handle fast curves better.

All right, enough theory. Just what does all this mean when you are driving into a corner?

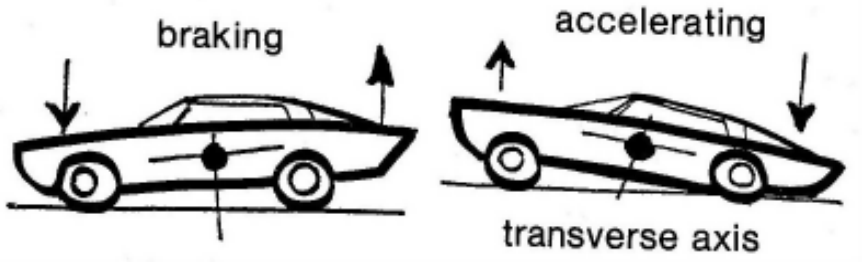
If your car understeers, the front tires are losing their grip or bite on the road, and the car is not turning into the corner properly. There are three things you can do:

1. Turn the wheel into the turn even sharper.
2. Lift off the gas gently and let the car slow down until the front wheels regain their traction.
3. If the car is in the right gear, your engine has enough torque and you have a delicate touch, you can apply a large amount of rear wheel spin to break the rear wheels loose and create an oversteer condition.

If the car oversteers, the rear tires are losing their grip on the road and the rear of the car is sliding out, causing the front to turn into the corner excessively. If this occurs, there is only one thing you can do.
Turn the steering wheel out of the turn thereby increasing the radius of the turn and reducing slippage at the rear wheels. NOTE! Do not touch the brakes as this will increase the severity of the skid.

WEIGHT TRANSFER

The springs or torsion bars support the largest part of a car. Because the springs are elastic and compressible, they allow the weight of the car to transfer under certain conditions. The weight transfers forward during braking, rearward during acceleration and sideways during cornering.



Since the additional weight transferred to a wheel adds to the traction limit of that wheel, we can do some interesting things.

We can, for example, in an understeering car, touch the brakes lightly and cause a weight transfer to the front, increase the traction limit and counteract the effect of understeer. We can also, in an oversteering car, accelerate gently, transfer weight to the rear, increase the rear traction limit and reduce the oversteer.

Remember that by transferring weight to one end of a car, we are moving it from the other end. This will produce a lighter load, less traction and perhaps a handling surprise if you are not ready.

BALANCE

Proper car balance is achieved when a car is driven smoothly. By this we mean no sudden or jerky braking or acceleration and smooth continuous cornering. A car that is driven out of balance will be “squirrelly” and difficult to control.

Occasionally we see a driver quickly moving the steering wheel back and forth wile entering a corner. This is called sawing and is to be avoided because it places the car into a series of short jerky movements that destroy its balance. The correct procedure is to enter the corner with one continuous uninterrupted turn of the wheel. It may be necessary to make rapid alternate steering corrections while drifting out of a corner. A good driver is sensitive to the behavior of the car and makes steering corrections while they are very small and almost unnoticed.

BALANCE (Continued)

One last word about balance. If you have missed your approach into a turn, it is better to go a little wide and sloppy than to force a last second correction that might get you in trouble.

SKID CONTROL

A skid can happen to anyone and at some point will happen to all of us. This need not be a big deal and cause a lot of panic as most untrained drivers sometimes think.

As you may recall, a skid occurs when the rear slip angle exceeds the front, and the rear wheels break loose and start to slide around. A skid very often begins as a wrong braking maneuver or by just driving a little beyond the limit in a corner.

Correcting a skid is just like you do on the ice, gently, slowly, and carefully.

1. Keep a cool head and don't panic.
2. DO NOT TOUCH THE BRAKES.
3. Gently turn the steering wheel into the direction of the skid.
4. If the skid is a mild one, you should be able to catch and correct it easily.
5. After you have caught the initial skid you must be alert for the counter skid that will start because of over-correction. The second skid will be milder, unless you have really over-corrected. Correct this skid the same way.
6. The moment the car has stopped swinging, gently turn into the direction of travel.
7. If the skid is severe, but you are in the right gear and have a sensitive touch on the gas, you could apply the gas as you steer into the skid. This requires practice.
8. If you were really into a corner over your head, the skid may be so severe that you may not be able to react fast enough to correct it. If you lost it entirely you can still catch is as it comes around. This technique is simple, put the clutch in and turn the wheel straight ahead, and wait. The car should come out of the skid and just roll backwards.

SKID CONTROL (Continued)

REACTION TIME

We all know that drivers have reaction times. This is the time it takes a driver to respond. This might range anywhere from 0.25 to 0.5 second. Cars also have a reaction time from 0.25 to 2 seconds. In order to brake, corner, or shift with precision, it is necessary to anticipate the car's reaction time. This means turning into a corner slightly earlier at higher speeds or shifting slightly earlier.

The ability to anticipate is what matters most in the making of a safe, fast driver. High speeds can only be driven in safety if the driver uses adequate foresight. Not only should a driver know how the car is going to react, but must also observe other drivers and their actions as well as constantly evaluate the condition of the course.

BRAKE POINTS

In order to turn a good lap you must go as fast as you can for as long as you can! Obviously, there are corners which cannot be driven flat out and you will have to slow for them. The rule is, brake as hard as you can as late as you can! Your hardest braking should be on the straight before a corner, not in the corner.

Not everyone has the excellent depth perception necessary to drive deep into a turn before deciding to brake. Fortunately, it is not necessary. If you will pick out a spot or marker on the side of the road leading into the corner, you can use this as a braking point. Do not listen to anyone else's tale of where they brake before a corner. This must be determined by you and only you. It is something you should work up to, noting at what point you begin braking, and going a little deeper, braking a little later each time.

DOWN SHIFTING

In order to accelerate quickly after a corner, the car must be shifted to the appropriate lower gear before the corner. Naturally, this should be done as late as possible preferably at the same time as we are braking hard for the corner.

This presents a small problem. If we are braking and shifting, our right foot is on the brake and left foot on the clutch. The engine RPM's will drop quite low and when we let the clutch out we will "pop" or jerk the rear wheels. This sudden jerk acts as an additional brake, and could cause the rear wheels to exceed their traction limit and cause a skid.

But what else can we do, we only have two feet! The solution is simple. During braking, the ball of the right foot remains on the brake pedal and the heel of the foot applies the necessary amount of gas to raise the RPM's up to where they should be. Where they should be can be determined at any speed for any gear by the gear chart. This process is called heel and toe and is very important and should be thoroughly practiced until it becomes second nature. Not only does heel and toe save time, but it provides a sense of control and safety.

DOWN SHIFTING (Continued)

There is another technique that racing drivers use during a downshift that helps achieve smoothness, eliminate possible clutch slippage and extend the life of the transmission syncro rings. It is called double clutching (or more properly – double de-clutching). Her is how it works:

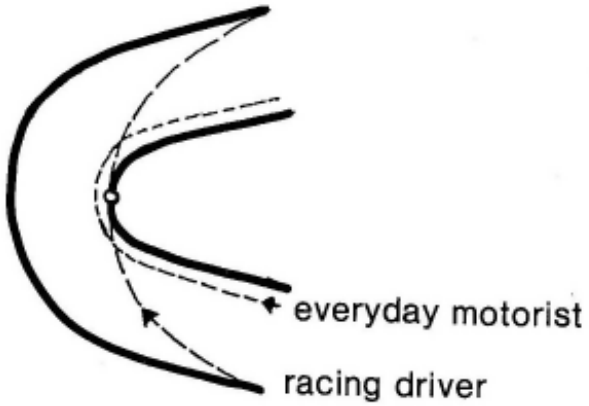
1. Put the clutch in.
2. Move the shift lever to neutral.
3. Let the clutch out.
4. Rev the engine slightly higher than the minimum revs required for the down shift.
5. Push the clutch in, and,
6. Quickly slip the gear shift lever into the desired lower gear.

When driving at high speed along a straight that ends with a slow curve, many drivers down shift through each gear, letting the engine resistance slow the car even while braking. This procedure should be followed only if you are running an endurance race and need to save the brakes. It is much faster and precise to use the brakes hard and to shift directly to the lower gear you will be using. Be sure the engine RPM's are correct for the lower gear or else you might over-rev the engine.

LARGEST POSSIBLE RADIUS

The cornering speed that can be attained depends on the radius of the curve. The larger the radius, the higher the attainable speed.

The principle of cornering is to strive for the maximum possible radius that can be drawn within the road surface of a corner.



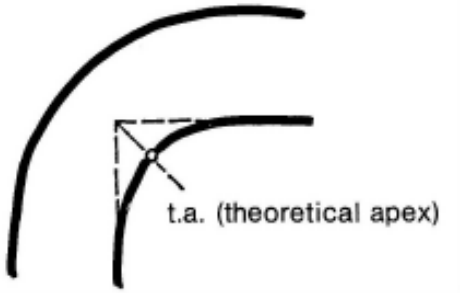
LARGEST POSSIBLE RADIUS (Continued)

Since the largest possible radius allows higher cornering speeds, it also means less braking before the corner, moving the braking point closer to the corner, allowing the car to stay under power longer.

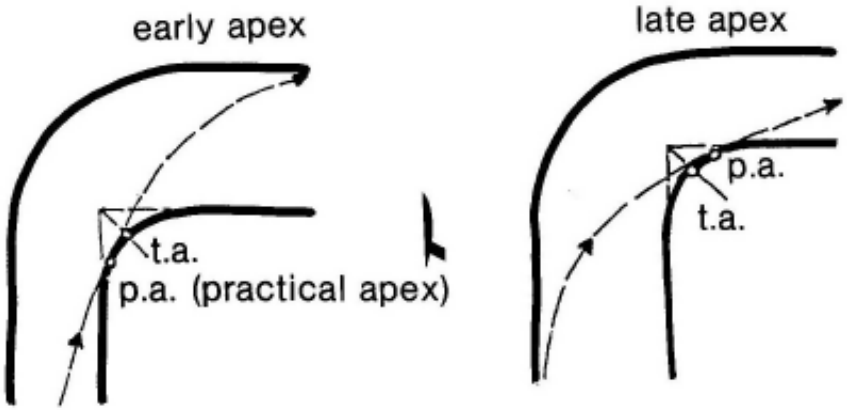
THE APEX

There are several different kinds of apexes. This first is the theoretically or geometrical apex. The theoretical apex is that point where the largest possible radius touches the inside middle of a turn.

It can be determined by bisecting the angle formed by extending the edges of the road.

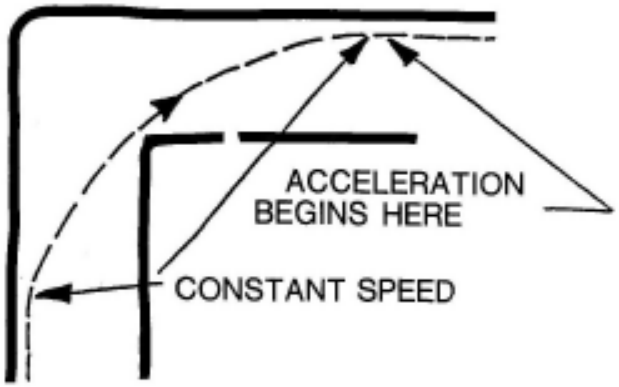


The point a car traveling on the ideal line touches the inside middle of a curve is called the **practical apex**. When the practical apex comes before the theoretical apex, we call it an **early apex corner**. When the practical apex comes after the theoretical apex, we call it a **late apex corner**.



THE CORNER

As we said earlier, the faster possible speed around a corner is obtained by driving a line formed by the largest possible radius.



A high performance driver, however, is not concerned with driving as fast as possible around any one corner, but rather how to produce the lowest lap time for the entire course. To achieve a low lap time, we must go as fast as we can for as long as we can. The higher the speed attained, the more time we save. This means that the speed we are able to reach on the straights is most important. It is necessary to consider not only corners themselves but also the straights leading into the corners and the straights coming out of the corners.

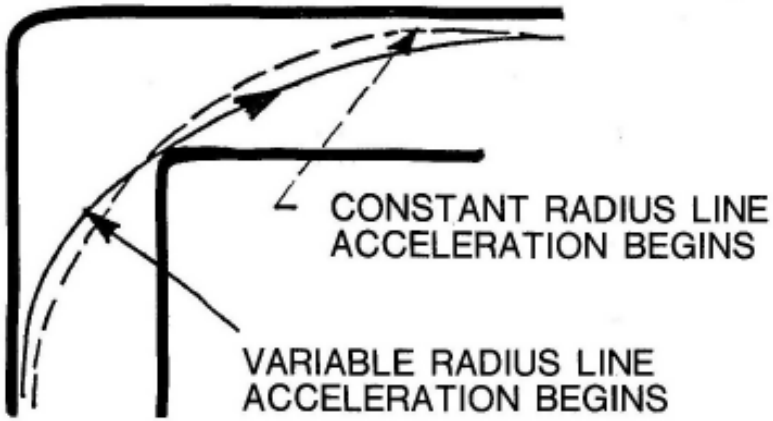
Acceleration and deceleration are identical forces operating in opposite directions. But for a car, the forces during deceleration (or braking) is much greater, almost double that of acceleration.

A vehicle can be stopped in half the distance it takes to accelerate it. Therefore, we must allow as much time as possible for acceleration and exit speed and exit line become more important than entrance speed and line.

For a given radius curve and traction limit there is a speed that can not be exceeded if the car is going to stay on the road. This means that if a car is being driven around a corner at the maximum permissible speed (traction limit) it can not be accelerated until it has reached the end of the corner.

In order to reach the straight after a corner at a higher speed, we must straighten our exit line so that less traction is used for cornering and more traction is available for acceleration.

THE CORNER (Continued)



Since we can begin to accelerate earlier, we achieve a faster exit speed entering the straight and can reach a higher speed on the straight. This is an application of a late apex, which is used when a straight follows a curve.

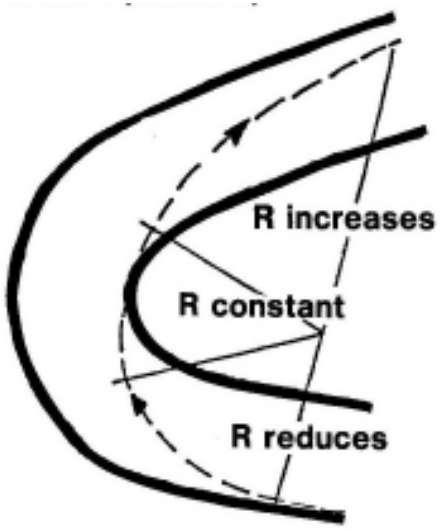
Just how much we should change our line from the largest possible radius line (or theoretical apex line) depends on the performance of the car. If your car has only enough power to drive along the curve and can not be accelerated beyond its traction limit, the largest possible radius line or theoretical apex line is the obvious choice.

If, on the other hand, your car has lots of acceleration, it will be necessary to straighten the exit line considerably to be able to accelerate as early as possible.

For cars somewhere between, you will need to experiment and practice until you find the right line for your car.

You may have noticed that when we changed our exit line to make it straighter, we caused a much sharper curve at the beginning of the curve. This small radius turn must be driven slower.

SETTING UP A DRIFT (Continued)

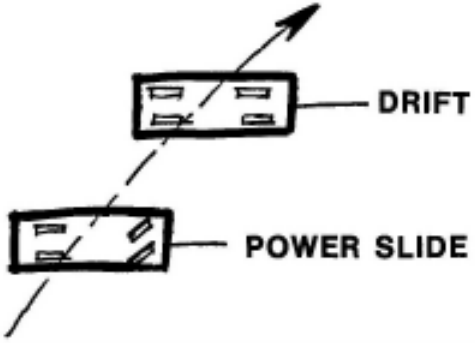


If a car is cornering as quickly as possible, it must be kept at the limit of adhesion from the moment it enters a corner until it exits the corner.

The fastest way around a corner which produces the highest exit speed is called drift. A drift is a state of equilibrium between rolling and sliding. We say a car is drifting when the front wheels are turned into the turn or straight ahead and the rear wheels are approaching their traction limit, and the car is gaining speed.

If the front wheels must be turned out of the turn in order to maintain the rear traction limit, we call is a **power slide**.

If all four wheels are sliding, we refer to it as a **broadside**.

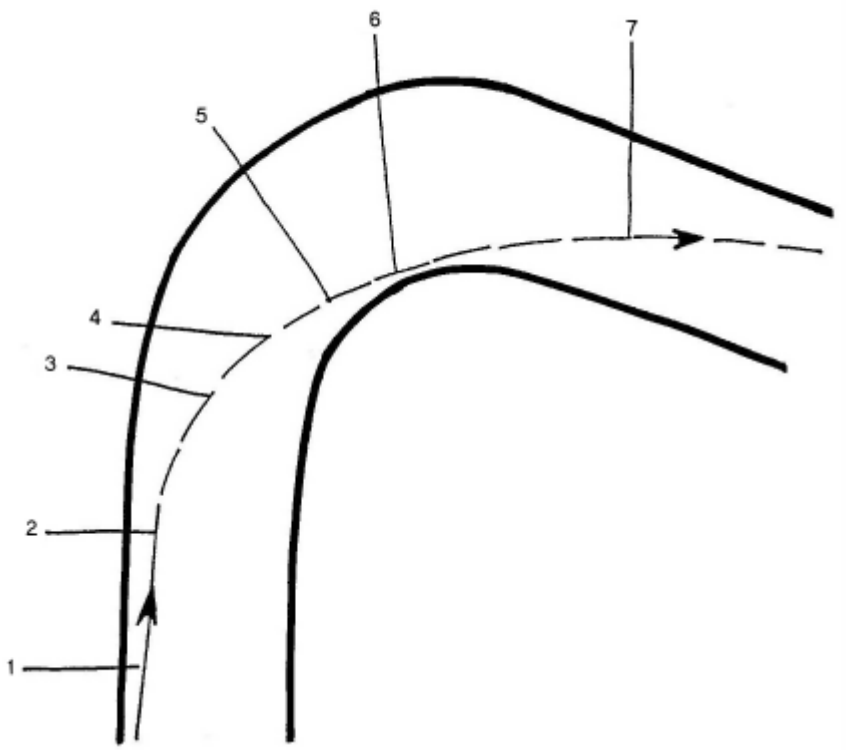


SETTING UP A DRIFT (Continued)

In practice, the differences between a drift and powerslide are very subtle. The drift generally referring to an equilibrium state and the slide being a corrective action to achieve or maintain the drift.

This drifting technique is for experienced driver only!

So, how do I go about making a car drift?
Let's take it a step at a time:



SETTING UP A DRIFT (Continued)

1. **Hard Braking and Downshift**
   Hard braking should be completed while the car is traveling in a straight line, and before the corner. Be sure to use your heel and toe technique to equalize the RPM's and avoid a sudden jerk.
2. **Decreasing Radius**
   Turn into the corner with one large continuous turn of the wheel. The turn should be quite sharp but must be a smooth one-piece motion. If the turn is too sharp, you will wind up with an understeer condition.
3. **Trailing Brake**
   After completing the hard braking, do not remove your foot from the brake, but rather continue braking very lightly. This continued braking action will cause a weight transfer toward the front of the car. This will increase the traction limit at the front and give the tires a better grip, allowing you to turn more quickly. It will also reduce traction at the rear to help set up our drift.
4. **Light Acceleration**
   As the rear wheels lose traction and begin to slide, we gently accelerate. The resultant weight transfer and increased wheel spin, up to the traction limit, keep the rear wheels from sliding out, but accelerates the car in the direction of travel at a drift angle.
5. **Balance Point**
   As we gradually accelerate, we begin to turn the steering wheel out of the turn. At this point in the turn, the front wheels are straight ahead. If we are in equilibrium of the traction limit and drift angle, we should need little or no steering correction.
6. **Throttle Steer**
   We still have not yet reached our apex, yet we are accelerating quickly. Some steering correction might be necessary at this point and should be done delicately and precisely, using both steering lock and the accelerator.
7. **Maximum Acceleration**
   Full throttle is applied just past our apex. If we are not accelerating at or near the limit of traction at this stage, then we have entered the beginning of the turn too slowly and should increase our entry speed next lap.

SETTING UP A DRIFT (Continued)

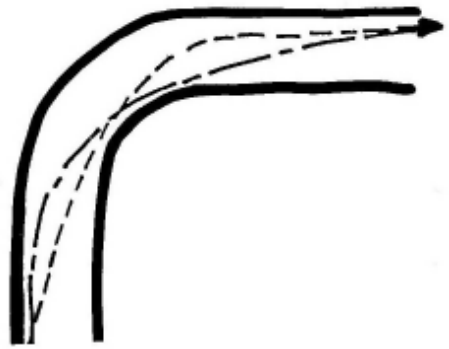
When approaching a corner, it is important to pick out a spot or marker close to your intended apex. As you begin to set up for the apex your eyes should be on your apex. Keep your eyes glued to your apex until you are almost past it. Inches count and you should try to place a front wheel about 6 inches from the apex, consistently, lap after lap.

A common tendency for untrained drivers is to tilt or allow their heads to lean excessively toward the side while corner. Do not do this. Your depth perception and vision is greatly impaired. Try tilting this page twenty degrees and read it quickly. Try to keep your head up and your eyes parallel with the horizon.

EARLY APEX

When a straight follows a turn we call it Type I Turn, and use the late apex technique.

When a straight leads into a turn and is not followed by another straight is it called a Type II Turn and we use an early apex technique.



An early apex line is the same as a late apex except it is just the opposite. Instead of using a long, shallow exit for acceleration, we use a long shallow entrance for braking. This allows you to extend the straight that precedes this corner and brake much later. Of course, you can not exit from the corner very fast, but that is all right if there really is no place to go fast anyway.

Someday you may find yourself heading into a corner much too fast to make the turn. The result is usually to go off the road or spin. One way to salvage the situation is to aim the car at the inside of the curve (early apex) and stay on the brakes. The corner will be sharper than usual, but you will be going much slower and the danger will be minimized.

ANALYZING THE COURSE

Before setting a wheel on any course, it is important to analyze the course and become familiar with its irregularities.

Start with a map or drawing of the course. It will tell you which way the course goes, where the corners and straights are and a good idea of the shape of various corners. It will not tell you if certain areas are uphill or downhill or what the road surface is like.

The next step is to walk the course. Start at the start/finish area and walk around the course with a map if possible. If the course is excessively long try to get a touring ride with an instructor while the track is shutdown.

Examine the track surface very carefully, because it has a very definite effect on your traction limit. Look for new asphalt that might be oily and slippery or old asphalt that might be chunking and breaking up. Certain areas near the apex of corners have grooves worn into them. Also look for areas of the course that might have loose gravel, sand or dirt on the road surface.

In short, look for any surface condition that might have an effect on your traction limit and mark your map accordingly.

Corners which come at the end of a straight require hard braking as late as possible. Look for good braking point markers prior to entering the corner. Signs, trees, fence posts, etc. will do nicely, just be sure your brake point marker will not be picked up and leave or get blown away.

Now look for apex areas. For Drivers Education events, an orange cone may identify the apex areas. Worn pavement is also frequently a clue. Look for the groove of tire tracks formed by other cars, but remember, you have to determine your own line. Again, mark your map with the apex of each corner and its appropriate marker.

Although the secret of good road racing is to stay on the road, that is not always possible, particularly while you are learning. If we were to spin off the road, most areas off the course would be safe, but some are not.

Look for dangerous areas where it would be a very bad idea to lose control and indicate them on your map. Look for trees, concrete walls, clay banks, bridges, lakes and ponds, cliffs and steep slopes, etc. Carefully examine your escape road where your emergency early apex will place you.

The high performance driver uses favorable road conditions to his advantage and avoids or minimizes the disadvantages of unfavorable conditions. Areas of the track that are uphill, banked, or smooth can be used to your advantage. Areas that are downhill, reverse camber, bumpy or might collect water work to your disadvantage.

It takes many, many hours on the course to learn all of these conditions so write them down on your map.

After you have walked the course, drive or ride around the course slowly. Some conditions are apparent when driving that are not apparent on foot, or vice versa. As you circle the course with gradually increasing speed, you will have to update your map for some factors will no longer be relevant, while others will assume new importance.

COURSE EVALUATION

As mentioned before, to achieve good lap times we must go as fast as we can for as long as we can. This makes the longest straight very important, but it makes the corner preceding it even more important, because it gives us a flying start down the straight. All corners which empty onto straights are extremely important and must be driven using a late apex or Type I Turn method.

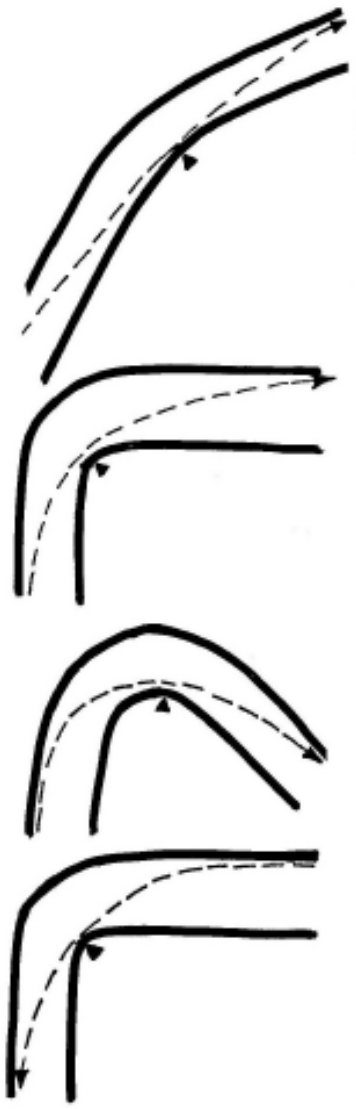
Corners at the end of straights, provided they are not followed by a straight, are of lesser importance, and we should use the early apex or Type II Turn method. If a turn can be driven either as Type I or Type II Turns, always treat it as a Type I.

Corners that empty into another corner are called Type III Corners. They are limited as to how fast they may be driven, yet cause a great deal of lost time if not driven properly.

TYPES OF CURVES

Not all corners are as conveniently shaped as the ones we have covered so far.

TYPES OF CURVES (Continued)

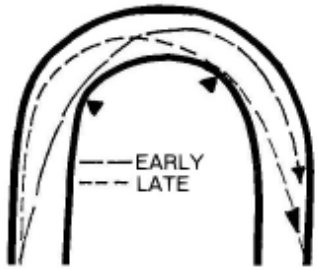


LONG CURVES (SWEEPERS): Long, flat, shallow curves can be driven at very high speeds because not much of our traction limit is used for cornering. The correct line for a sweeper is almost the same as the largest possible radius. Be sure to use as much of the road as possible. Bring your apex in tight because a difference of just a few feet at the apex has a very large effect on the radius of the curve and the speed that can be driven. Pick out your apex as your approach, keep your eye on it, and keep the car lined up with it. After you pass the apex, gently let the car ease out to the outside of the road.

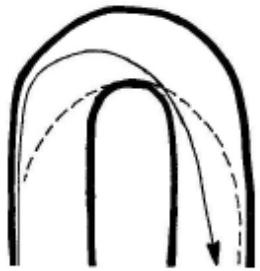
INCREASING RADIUS: A turn that tends to open up or get wider and wider can be formed by the actual curve of the road or by a curve with an equal road width. This turn calls for a slightly early apex with full acceleration during the exit. Do not “hug the rail”, let the car drift to the outside as you apply maximum acceleration.

DECREASING RADIUS: This is the most dangerous turn you will face. It gets tighter and tighter and requires patience and practice to get thru because the second half of the corner is frequently not visible and it is easily mistaken for a constant radius turn. That leads to an apex that is too early and the next thing you know, you are accelerating right off the road. The proper line requires staying very wide as long as possible, usually until you can see the exit line, before beginning to accelerate. A decreasing radius turn calls for a very late apex. If in doubt, stay wide and use a late apex, it is safer and all you will lose is time. Treat decreasing radius corners with respect.

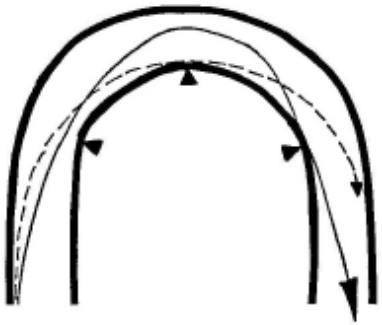
TYPES OF CURVES (Continued)



CONSTANT RADIUS: A constant radius turn can be taken in a number of ways. If a turn occurs at the beginning of a straight, it should be treated as a Type I Turn with a late apex and highest exit speed. If the turn occurs at the end of a straight and is followed by another curve, it is a Type II Turn and should be driven with an early apex. If it occurs between two corners, treat it as a Type III and drive along the largest possible radius.



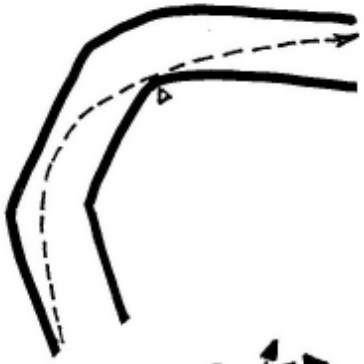
HAIRPIN: A hairpin is a very, very tight, constant radius turn, usually preceded and followed by a straight. It is the epitome of a Type I Turn. A hairpin can only be driven at very low speeds. Remember that a car will understeer when turned very sharply, which will excessively increase the turning radius of the car. The car should be braked very hard and the corner approached slowly. Using a trailing brake, turn the wheel to full lock and then begin accelerating. A hairpin has the latest apex of any turn. Remember, slow in, fast out.



CAROUSEL: Is another constant radius turn but has a very large radius. So large in fact that it is frequently desirable to make two turns out of it. Exactly how a carousel is to be driven depends on the performance of the car. Low performance cars should drive the LPR (longest possible radius), and the apex may not be a point at all, but a complete section of road or continuous apex.

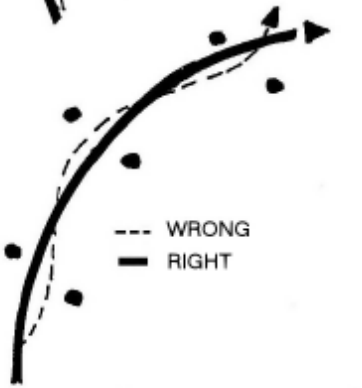
Very high performance cars develop such high speeds that they treat a carousel as a simple late apex constant radius turn.

TYPES OF CURVES (Continued)

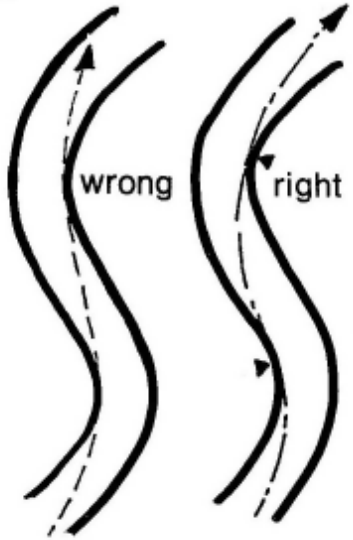


The rest of us might consider treating the carousel as two turns. The first half of the turn as an early apex, and the second half as a late apex line. Note that the turn actually has two apexes.

IRREGULAR: An irregular shaped curve is frequently made up of several turns in succession which may be driven as if it were one curve only. You must ignore the immaterial curves and select entry, apex and exit points that allow the series to be driven in one continues curve.



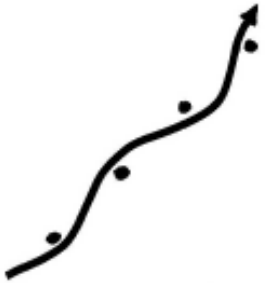
COMPOUND CURVES: Compound curve turns are made up of several turns in succession that cannot be driven as one curve. These Type III Turns do not allow you to make up much time, but can cause a lot of lost time if incorrectly driven. The reason is that the correct line for the first turn may put us in a bad position for the next turn. It may, in a series of blind turns, even put us off the road.



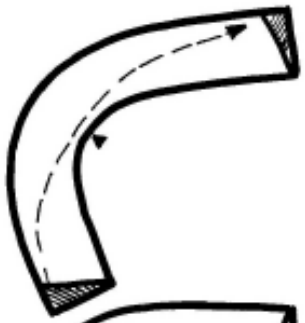
The last turn is the most important and we should exit at the highest possible speed. Select the best line for the last turn. Then determine what line is necessary in the turn **before** the last so that our entry into the last turn is correct. This may mean driving a line that appears "wrong" for each curve but produces the highest final exit speed. Low performance cars are inclined to treat each bend individually whereas fast cars connect the turns so quickly that they must be driven as a coherent sequence.

"S" Curves are examples of compound curves. Esses are transition curves in which the weight of the car transfers from one side to the other and back again, and must be driven very smoothly. Avoid any harsh or jerky movements.

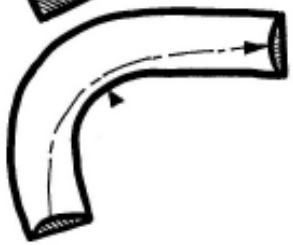
TYPES OF CURVES (Continued)



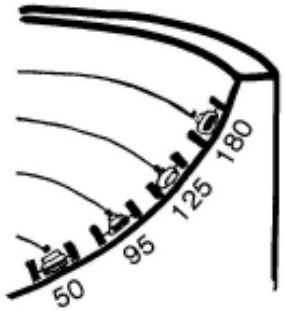
Slaloms are a special kind of compound curve. Driving slalom requires a steady rate of speed. Speed can only be increased when a smooth rhythm is established. Since slaloms are usually sharp slow speed turns, under steer will become apparent. As a result, it will be necessary to turn the wheel slightly earlier and somewhat quicker than usual. The tires need time to react. Above all, maintain a steady rhythm from beginning to end. Braking should be done before entering the slalom, never while in it.



Banked curves, with just a few degrees of banking allows a faster speed because the net effect of the bank is to straighten the road. This produces a very weird looking line thru the corner, which must be driven to be understood. The sharpest turns are taken at the beginning and the end of the turn at the outside where the bank is steepest and the curve is flattened when the car reaches the apex.



Crowned or Domed profile roads are roads that have a higher center section to allow water to drain to the outside. As a result, the inside edge along a turn acts like a banked road. To take advantage of the bank, it becomes necessary to almost "hug the rail". Driving along the outside edge produces an off-camber turn which results in considerate lost adhesion. Driving a normal LPR (largest possible radius) line produces a "cross over" effect as the banking change toward and away from us and can be very difficult to handle.



Monza Wall or very steeply banked turns are really deceptive turns. Since each degree of banking has the property of straightening out a turn, a steeply banked turn is not a turn at all but a straight. Each height on the banking has its corresponding speed limit. Any car driven at that limit will automatically find its groove in a band at a certain height along the bank.

STEERING AND HANDLING

Reaction Time: The time it takes for something to occur. Usually the time it takes a driver to respond after some indication requiring a response (about 0.25 to 0.50 seconds). Cars also have a reaction time to inputs from the driver and are approximately 0.25 to 2 seconds

Center of Gravity: The point within the car where it is exactly balanced in all directions

Weight Transfer: The transfer of weight from one side of the car to the other or front to back due to acceleration or deceleration

Lateral Resistance: The side force generated by a tire when cornering

Slip Angle: The angle between the direction a tire is pointing and the direction it is rolling while negotiating a turn

Lock: A turn of the steering wheel

Sawing: Rapid oscillations of the steering wheel by the driver while turning into a turn. It is an incorrect procedure

Head Lean: Leaning the head excessively while negotiating turn type maneuvers

Understeer: A condition during cornering when the car wants to go straight and it takes additional steering effort to make the car negotiate the corner

Oversteer: A condition during cornering when the car wants to turn into the corner sharply and the back end tries to break loose. An over reactive car

Neutral Steering: When the car neither oversteers nor understeers so that all four wheels begin to and maintain the same sliding characteristics

Plowing or Pushing: A slang expression for excessive understeer in turns

Hanging It Out: A slang expression for purposefully driving with oversteer, that is with a controlled sort of rear end skid

Drift: Driving a state of controlled skid, while the car is gaining speed

Skid: To make the tires slide rather than roll when braking, or to skid sideways

Braking Drift: The tendency of the car to skid when braked in a turn

Power Slide: Driving with oversteer induced by applying the gas

Spin: An uncontrolled slide or skid

Scrubbing: Causing the wheels to skid rather than roll, which greatly decreases the vehicles speed

Broad Slide: A controlled slide or skid which causes the vehicle to lose speed. Usually mistaken for a drift

Throttle Steer: Applying the gas to introduce a steering action. Usually while exiting a turn

Feathering: To apply accelerator pedal pressure gently

Heel & Toe: To use the ball of the foot on the brake pedal while the heel is used to control the gas pedal

ENGINE AND TRANSMISSION

Power Curve: The relationship between the horsepower available from the engine at each and every engine speed

RPM: Revolutions per minute how "fast " the engine is going

REVS: Slang expression for the above

Over-Rev: To run the engine at more revolutions per minutes than is desirable or good for the engine. Total engine failure may occur with an over-rev

Lug: To require large power outputs (step on the gas hard) at too low an engine speed than is good for the engine

GLOSSARY (Continued)

ENGINE AND TRANSMISSION (Continued)

Torque: The ability of the engine to produce twisting force

Max Torque: The maximum value of the torque value and the RPM at which it occurs

Shift Point: The RPM at which one shifts to another gear, either as an upshift or downshift

Red Line: A designated range of RPM values where possible engine damage or power loss occurs. It is not recommended to drive in this range

Upshift: To go from a lower to a higher gear as from first to second to third

Downshift: To go from a higher to a lower gear as from fifth to third

Double Clutch: To release the clutch in the middle of a gear shift as the shift lever passes through the neutral position. It is used to help extend the life of the transmission synchro rings

Gear Chart: A chart slowing the speed in each gear for various engine speeds

Riding the Clutch: Driving with the clutch partially disengaged or with excessive clutch slip in making shifts

Slip (as in clutch): When one allows the engine to run fast while the car proceeds slowly (as in holding a car on a slope by holding the clutch out slightly)

Accelerate: To increase vehicle speed, usually at its maximum rate

Decelerate: To decrease the vehicle speed

TIRES AND BRAKES

Contact Patch: The small, about 30 to 60 square inches, area of the tire actually on the ground at any instant

Coefficient of Friction: The ratio of the force a tire can generate to its load. Typically, values range from a near zero to approximately one

Traction: The ability of a tire to adhere to a road surface. It is a function of weight and tire contact area

Traction Limit: The maximum forward, rearward, or sideward force at the tires while accelerating, braking or cornering

Wheel Spin: To actually spin the wheels when accelerating

Pumping Brakes: Modulating the brake pedal to raise the fluid level. It is not a braking technique

Cadence Braking: Actually modulating the brake pedal pressure to maintain maximum braking

Jabbing Brakes: Sudden repeated brake pedal actuations that alternately skids the tires. A poor application of the cadence brakes concept

Lifting Off: To let upon the gas pedal to allow the engine to slow the vehicle

Hard Braking: To decelerate using the brakes to thieir maximum capacity

Trailing Brakes: Maintain a low and decreasing level of brake application into a turn in contrast to complete release of the brakes before beginning the turn

GLOSSARY (Continued)

TIRES AND BRAKES (Continued)

Braking Point: A designated point at which you begin to apply the brakes, usually a fixed distance from a turn or other location, which requires lower speed

Stopping Distance: The distance required to stop the car from a specified speed (usually means minimum distance and may or may not include time required for the driver to actuate the brakes after an indication braking is necessary)

Rolling Resistance: The force required to make a tire roll, as when pushing the car

Balance: The relationship between the load on the individual wheels and their ability to turn, brake, or apply power. If they are near equal, the balance is good

Roads & Curves

Radius: The distance from the center of the circle to the local path the car is maintaining

Largest Possible Radius: The largest radius that can be drawn and still stay on the road surface at the start, apex, and end. Fastest line through a given corner

Theoretical Apex: A point along a curve where the largest possible radius touches the inside edge of the turn

Practical Apex: A point along a curve where the path of the car should touch the inside edge of the turn.

Clipping Point: A point along a curve where a car actually touches the inside edge of the road

Early Apex: When the practical apex occurs before the theoretical one

Late Apex: The counterpart of the above, when the practical apex occurs after the theoretical one

Ideal Line: The best possible path through a turn considering all factors

Entry Point: The point at which one begins the turning maneuver

Exit Point Line: The desired direction (path) at the point of exit from a cornering maneuver

Off Camber: When the road slopes away from the inside (the side about which the car is turning) of the turn

Straights: A portion of road or track where the vehicle must only basically increase or maintain its speed

Constant Arc: When the radius of the turn is constant

Decreasing Radius Turn: A turn which gets sharper and sharper and sharper and…

Increasing Radius Turn: A turn that gets wider and wider and wider and…

S Curve: A curve like an S; two or more connected turns which alternate direction

Slalom: To weave between a series of designated markers or obstacles

Hairpin: A very sharp turn which causes the road to exactly reverse its direction in a little over two widths of road

Type I Turn: A turn followed by a straight road

Type II Turn: A turn at the end of a straight road and not followed by a straight road

Type III Turn: Those types of turns not included above

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