The Art of Braking and Car Control

THEORY 101

A race car driver makes hundreds of decisions per lap under constantly varying track and car conditions. When to initiate a turn, when and how hard to brake, when to get on the throttle, etc. etc. lap after lap; decisions, decisions… Throw in a bunch of other fast-moving cars and in addition to all the previous variables, you now have to avoid hitting the aforementioned vehicles; and, if you want to win, you'll need to actually pass them! To do this, within the excitement of a race, you must now try to identify, and then take advantage of, the next driver's minute timing error to execute a pass. Just another morning commute on the Katy freeway!

Of all the skills a race car driver must master to be quick around a racetrack, none is more complex or critical than braking. Few racing skills are harder to learn than the ability to slow a race car at the limits of its braking capacity. Slow down too much or too slowly and you've lost critical lap time. Slow down too little or too late and you'll be in serious trouble, fast!

TRIVIA 1
At 150 mph a car travels 220 feet/second.

Telemetry shows that Michael Schumacher spent less total time on the brakes than any other Formula One driver. In other words, he was more effective with his braking than any of his competitors. Most passing in a race is done under braking, going into a turn. Half a second, the time it takes your brain to decide to step on the brake, is 110 feet; you just got passed and your competitor is on his way to winning the race!

Racecar drivers are very experienced in braking for maximum effectiveness. The everyday driver, however, seldom experiences braking at the limit and most have no idea what antilock braking feels like. When we do brake at the limit, it's usually in an emergency for which we are not prepared. After this weekend, we hope all of you will be better drivers, and better judges of what it takes to slow your car from 50 mph or even 25 mph. If all of us knew what it takes in time and distance to slow down, our streets would be much safer places.

The responsiveness of the car, the quickness with which it responds to your inputs, is in direct proportion to its "stiffness". It is also proportional to the speed at which you travel as at high speed your inputs are magnified and the consequences of your actions are much greater. You will probably be OK if you miss an apex by two feet at 60 mph. If you miss by the same two feet at 120 mph going into Turn 1 at Texas World Speedway, you will end up in Mexico.

Whenever we accelerate, brake or turn from side to side, we shift the weight of the car. In a streetcar (yes, your Porsche IS a streetcar) the shift is not instantaneous as there are suspension components, including the tires, designed to cushion its occupants. The ultimate expression of road isolation were American land yachts of the 60s designed to travel interstates at a leisurely sleep-inducing pace where nothing would be allowed to spill a drop of your 64oz Slurpee®. Managing your car's weight transfers is the essence of high speed driving and the most powerful tool at your disposal is your car's braking system.

TRIVIA 2

The total suspension travel in a modern F1 car is less than 1/4".

PRACTICE 101

All students attend a braking class during which you will systematically learn the capabilities of your brakes and learn a trick or two for use on the track.

THEORY 201

Brakes are an incredibly powerful tool - they are 3 to 5 times more powerful in their stopping ability as compared to the engine's ability to accelerate the car. But most of us do not pay very much attention to how we use the brake pedal. We put a lot of thought into the use of the steering wheel and a fair amount of thought into the use of the throttle. But when it comes to the braking, we generally just put our foot on the pedal, then push harder and harder until we achieve our desired braking. And most of us brake the same way, regardless of whether it is an unscheduled panic stop, or a planned stop for a Stop sign or a corner.

TRIVIA 3

A Formula One car can go from 180mph to 0mph in 4 seconds flat, a little longer than if it hit a wall. Most of us would lose consciousness if we were passengers; if we wore contact lenses, they would be plastered to the inside of our visors.

When you step on your car's brakes, inertia transfers weight to the front and the car dips. Conversely, under acceleration, it is the rear that hunkers down as you gain speed. Front brakes are designed to provide roughly 70% of the stopping power and are therefore larger than the rear (if the rear brakes locked up first, the car would likely spin out of control). If you stomp on your car's brake pedal it is sometimes possible to lock the front brakes before the weight is transferred therefore reducing their efficiency.

TRIVIA 4

Racecars don't have anti-lock brakes as ABS is designed to allow the driver to maintain steering control in a panic stop. Racers can actually slow their racecars faster without ABS, but we "normal" drivers need ABS to prevent lockups and maintain control.

PRACTICE 201

The most efficient way to stop a car is by braking in a straight line. Students are given a practical demonstration of the contact patch, the cumulative total surface area of tire rubber in contact with the ground and it how it can be used to its best advantage during the Threshold Braking exercise.

THEORY 301

If we are at maximum available braking, you cannot ask the contact patch to also start providing any sideways grip all at the same time – you will exceed available the limits of the tires.

Let's say we did brake and turn at the same time, but kept the requested grip within what was available. We don't slide, but what happens when we take our foot off the brake? The car rocks back, and we un-weight the front tires, right in the middle of a corner, probably causing the car to understeer and run wide.

So, heavy braking as we lead up to and enter a corner causes all sorts of weight transfers.

Weight transfers are not a bad thing. What is bad is if the weight transfer runs counter to what we are trying to get the car to do, as when you suddenly un-weight the front of the car when you stop breaking in the middle of a corner.

What we really want is for weight transfers to occur smoothly and deliberately. We also want a car to be poised and balanced as we approach a corner.

The sequence through a turn is:

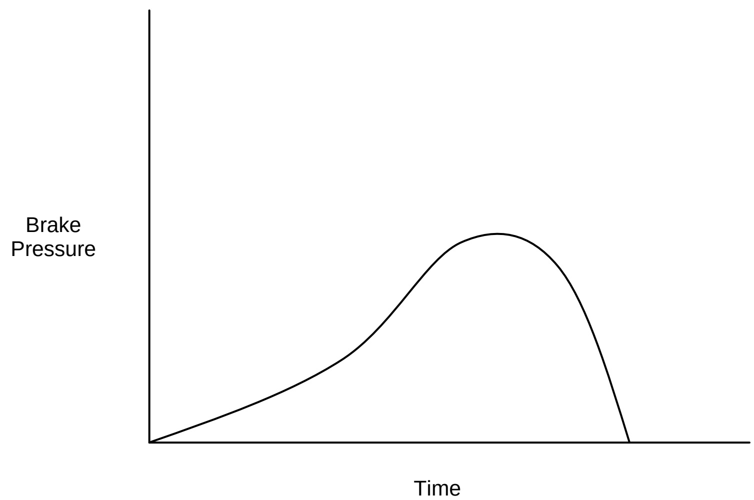
1. Brake in a straight line (shift weight of the car to the front).
2. Stop braking (end weight transfer to the front and start shift to the back).
3. Get on the gas (transfer weight to the back and hunker down the rear of car).
4. Set the suspension (when weight transfers to the back).
5. Turn.

TRIVIA 5

Water pressure in a new home is around 60-70 psi.
The braking system in a modern 911 can generate 2,000 psi.

So let's examine how most of us brake.

- We find the brake pedal, and we push harder and harder until we finish our braking maneuver, at which point we promptly take our foot off the brake.
- At the limit, this causes the car to be unstable just when we want it to be stable and balanced.
- In other words, it appears that it's more important how we come off the brakes than how we get on them.
- If you drew a chart of brake pedal pressure against time, it would look something like this:



At the same time, we want to keep our braking distances as short as possible, so we can go faster around the racetrack. How do we accomplish both of these? By inverting the whole braking technique – by braking hard in the early part of the braking maneuver, and reducing pedal pressure as we come off the brake.

So we push the brake pedal hard early, when the car is in a straight line anyway, and then come off the pedal gradually – giving the car the opportunity to settle and become balanced.

It still needs to be a smooth application – pushing hard early does not mean you are trying to snap your instructor's neck.

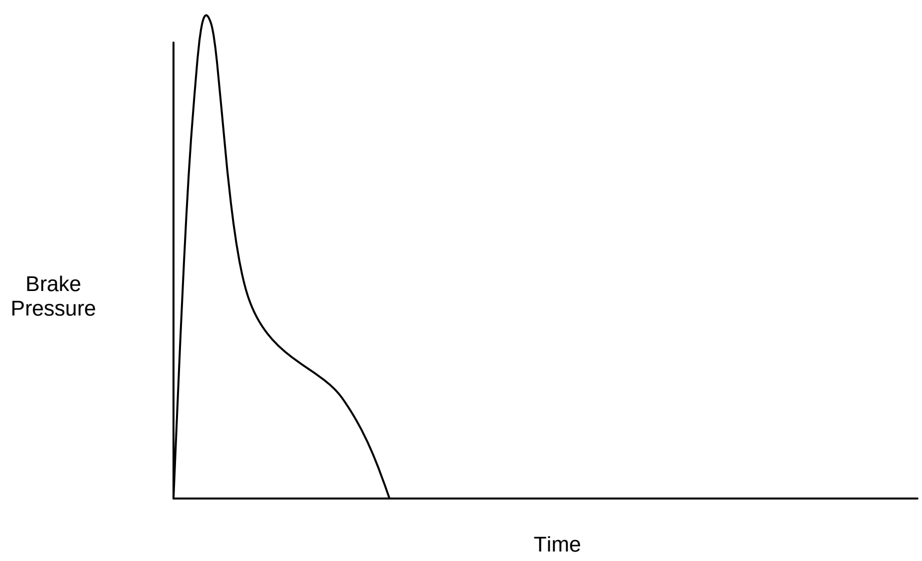
How much time should you spend on the two phases? You should think of it as a waltz beat – one on the push down, and two-three on the release.

This technique has at least three other benefits:

- First, you will be able to shift more easily since the shifting process will be completed early during hard braking.
- Second, the speeds of the engine and the drive train are more likely to be matched, so that you minimize the chance of having a braking effect from the engine when you let the clutch up.
- Third, the inverted braking technique helps if you have misjudged your braking point and started braking too late – you can stay in the brakes and have a better chance of recovery than if you had braked the other way.

For cars that do not have ABS, there is a fourth benefit – if you do happen to push the brake pedal too hard and lock up the front tires, it happens early in the braking maneuver. And since you had already intended to start releasing the brake pedal, you are more likely to recover and regain good grip.

If you drew a chart of the inverted braking technique, it would look something like this.



You should practice this inverted braking on the street. That doesn't mean that every stop needs to be accomplished in 60 feet – it is the shape of the braking profile that you should be practicing. And if you are going to try and brake in 60 feet on the street with the inverted braking technique, then be smart about it – don't do when there is an 18-wheeler 6 feet behind your rear bumper.

It may take time and practice to get proficient with this, so at first you may want to allow a little more distance to move up your braking points a bit earlier. But with time, it may even shorten your braking distances, since the car is more stable with this technique and you become more confident about the application of brakes.

PRACTICE 301

Our last part of the class is to actually practice the inverted braking technique by quickly slowing from about 60 to around 30 prior to turn in and acceleration.

CONCLUSION

Any time we turn our steering wheel we compromise braking efficiency and if we brake as we turn, the car becomes unbalanced and uncomfortable for our passengers. At the worst this can cause us to lose control of our vehicle. For comfort and safety, whenever possible, don't brake and turn at the same time. On your way home on Sunday try slowing down before you reach corners and gently power through them. You will notice the car is more stable and much more comfortable for your passengers.

FINISH YOUR BRAKING BEFORE YOU START YOUR TURNING

Over time, you will learn to use the brakes for all sorts of delicate weight transfer adjustments. You will learn to left-foot brake at the end of the front straight while under full acceleration. Why brake when under full power? Answer: To shift some weight to the front and have the car ready for the transition before the braking zone. The car is hunkered down and weight is evenly distributed on the four contact patches. Turns 4 and 6 at TWS are also good spots to left foot brake. Try braking with your left foot in daily driving.

Steering inputs are very similar to braking. Start your input smoothly then be precise. If you look at a Formula One driver's in-car camera you will notice that he is extremely precise with his steering input, he only turns as much as he needs to and he never has to correct in the middle of a turn.

Remember: brake, stop braking, squeeze on the gas, set the suspension and power through the turn. You should be under full acceleration at the apex of the turn with your engine's full torque being transferred to the ground. The car's weight will be centered on the contact patches as you power through the turn. You will feel the chassis flex in the seat of your pants and you will be one with the car. Exquisite delicacy and precision is rewarded with a perfectly executed turn. The next time you power through turn 7 at TWS, see if you don't feel this sensation. If this feeling gets you excited, **congratulations and welcome to the world of high-speed precision driving**!

Written by Ted Lazarides and Jack Smyth

