10/10ths MOTORSPORTS

The Black Crack Report

The addiction you don't want to fight

Issue 24, February 2011

2011 Event Schedule

We have added Mid Ohio to our event schedule this year and have also firmed out the first ever Charity Event at Putnam Park. I am looking forward to a great season and seeing all the 10/10ths drivers again at the track.

- **March 14th & 15th, 2011 (Mon/Tue) VIR**
- **April 2nd & 3rd, 2011 (Sat/Sun) Putnam Park**
- **May 7th & 8th, 2011 (Sat/Sun) Putnam Park**
- ***3 Balls Racing Event May 16th at Mid Ohio (Mon)***
- **July 2nd & 3rd, 2011 (Sat/Sun) Putnam Park**
- **July 30th, 2011 Horsepower4Hope Charity Track Event (Sat) Putnam Park**
- **July 31st, 2011 (Sun) Putnam Park**
- **August 11th, 2011 (Thur) Mid Ohio**
- ***3 Balls Racing Event September 19th at Mid Ohio (Mon)***
- **October 22nd & 23rd, 2011 (Sat/Sun) Putnam Park**
- **November 5th & 6th, 2011 (Sat/Sun) Carolina Motorsports Park**

One last major 10/10ths Race Car Upgrade for 2011 is on its way

What could it be? ☺ ☺

Muscle Cars:

10/10ths is developing a great relationship with the Muscle Car world and hopes to see many of these great cars at our events this year. I would like to thank Pro-Touring.com for their fantastic hospitality and help with getting involved with all the Muscle Car Drivers. 10/10ths had the priveledge last year to provide the instructors for the MidWest Muscle Car Challenge and we had a great time. I am hoping to be involved again in 2011.

10/10ths Tech Corner

Threshold braking or limit braking

Below is a great article I found on this subject and thought I would pass it along.

The technique involves the driver controlling the brake pedal (or lever) pressure to maximize the braking force developed by the tires. The optimal amount of braking force is developed at the point when the wheel just begins to slip. Braking beyond this point causes the tire to slide and the friction adhesion between the tire and driving surface is reduced. **The aim of threshold braking is to keep the amount of tire slip at the optimal amount, the value that produces the maximum frictional, and thus braking force.**

When wheels are slipping significantly (kinetic friction), the amount of friction available for braking is typically substantially less than when the wheels are not slipping (static friction), thereby reducing the braking force. Peak friction occurs between the static and dynamic endpoints, and this is the point that threshold braking tries to maintain.

Because available friction at a given moment depends on many factors including road surface material, temperature, tire rubber compound and wear, threshold braking is nearly impossible to consistently achieve during normal driving. In vehicles not equipped with anti-lock brakes (ABS) the following technique can be used to approximate threshold braking:

- Press the brake pedal about half way in, as if you were braking normally.
- Smoothly increase brake pedal pressure until wheels just start to slip and threaten to lock up. On dry, hard pavement you will start to hear a low-level squealing sound. On loose or slippery surfaces you will start to hear a low-level swashing sound. On all but the highest grip surfaces the front wheels will lock first by design in order to avoid oversteer.
- Reduce brake pedal pressure by a small amount, enough to diminish the squealing or swashing sound and allow the almost-slipping wheels increase their traction again.
- If more braking is desired, increase brake pedal pressure until the wheels threatens to lock up again, then release pressure, and so on.
- At all times, avoid actual locking of the wheels. Note that on slippery pavement if you actually lock up the brakes you will have to lift your foot almost entirely to regain wheel rotation.

A human driver can perform one press-release cycle per second with practice. The ultimate goal is to achieve constant brake pressure and tire traction across the entire braking process.

However, if the surface is bumpy or uneven, a threshold braking traction of constant value might not be achievable, so varying brake pressure as the vehicle rolls over each obstacle becomes the default performance action.

In a situation where a car needs to turn or swerve to avoid a collision but is traveling too fast the above technique allows the driver to retain steering control of the car while decelerating (though when turning brake pressure must be necessarily less). Simply standing on the brake pedal would lock up the front wheels with no possibility of changing the car's direction. Formula One drivers actually try to distribute tire traction between the braking process and the steering process in one smooth varying continuous whenever they negotiate turns.

It should be noted that most vehicles have four tires but of course only have one brake pedal controlling all four wheels. It is probable that one tire will lock before the others, particularly on an uneven road surface or on road debris. This is where independent four wheel ABS will outperform threshold braking in most real world situations because it is able to release the brake pressure on only the locked wheel, rather than on all four wheels as would be required with threshold braking.

Threshold braking is a technique for braking in motorsports. It's advantages are:

- **A minimal wear on the tires**: Probably the main consideration of threshold braking over locked wheels, is not the slightly decreased distance but the decreased wear of the tires and brakes. In this method, the front wheels are on the threshold of locking-up (without actually locking-up), which occurs in about 30% percent slippage. This causes minimal wear to the tires, thus keeping them intact (and hot), unlike locked wheels (which occurs at 80-100 percent slippage). This contributes to the braking distance, since a layer of melted rubber isn't being built up under the tire while braking. Theoretically, braking even less hard, with no slip, will make for even less wear, but this will cause the braking to be spread across a much larger area, resulting in more heat and possibly resulting in brake failure.

- **A maximal exploit of braking potential**: In this method, the car is, in most cases, slowing down as quickly as possible, especially on slippery roadways. It will stop you faster than any ABS, locked-wheels, or any other technique. That's because the wheels are still rolling, as slowly as possible (25% less than the car's speed), and are not locked. The wheels can therefore stop quicker than under skidding, especially in the wet, where locked-wheels float. Only on soft surfaces, primarily gravel, will locked-wheels stop you quicker. ABS systems imitate threshold braking, but in the process, there are intervals of either locking the wheel momentarily (in older systems), or applying a bit less pressure (in some of the newer systems). Therefore, threshold braking is generally better. This is important because, in theory, drivers need to brake as late as possible before corners. It's important to remember that locked-wheels are always better than almost anything short of threshold braking. Stopping faster is not always stopping better.

- **It is the most controlled method of braking**: Once wheels are locked on slippery roadways, you might find it hard to release them. Additionally, locked wheels are exploiting all available tire-adhesion for slowing down, so any steering is useless and will only make the braking distance longer. In threshold braking, the wheel is still responsive (Albeit crippled). Additionally, in threshold braking, there is still some slack in the dampers, allowing them to keep the wheels stuck on the road surface. In conditions of split-grip (two wheels on a different surface), threshold braking might be hard, or not as efficient as locking-up the tires.

However, threshold braking is hard to achieve. The point of threshold is not static, and the pressure on the pedal has to be modulated to keep the car braking at the threshold. A common mistake is to brake far too lightly (about 60%).Therefore, the suggested approach in a road car, is to stomp on the brakes and let locked-up wheels or ABS stop you. However, in a race, there are multiple ways of achieving threshold braking:

1. **Cadence braking**: a variety of method that involve pumping the brake, and therefore theoretically reaching through the threshold for small periods of time. This method is never advised due to a dramatically increased braking distance and a not necessarily improved control or steerability.

2. **Progressive braking**: A method of progressively squizzing the brake to the point of the threshold, and than keeping it there. While it is true that "stomping" on the brakes will not allow you to exploit the brake potential efficiently, modern brakes can still be pressed quite quickly in high efficiency, and therefore, squizzing it down will have you put in low pressure for quite some time.

3. **Regressive braking**: This is the suggested approach. It is better to start off hard and release, rather than go easy and increase. Yes, even if it costs a momentary lock-up or activating the ABS. That's because the hardest pressure is needed at the beginning of the process, when the car is still going very fast. Once you have reached the point of threshold, you will have to constantly release the brake pressure to keep it there. Ideally, you should start to brake hard, and then go through the entire braking zone gradually easing off, until you reach the turn-in with minimal or zero pressure. There are three methods of regressive braking:

- When caught under surprise: Brake as hard as possible, at once, and then release the locked wheels and keep them at the threshold by regressive braking.
- Before a typical racing corner, for beginners: Brake regressively and smoothly, but not necessarily at the exact threshold.

- Before sharp corners, advanced technique: This is the classic method of regressive or threshold braking that racing drivers should adopt. Sadly, it's also the hardest skill to adopt. Start braking hard, at the threshold, and then constantly release to keep it at the threshold. As you are about to corner, release more pressure, and enter the corner with slight brake pressure. You should combine this with Heel and Toe and possibly with trail braking.

Cadence braking

Cadence braking is commonly known as "pumping" on the brakes. In fact, correct "cadence braking" is more than just that, and it involves deeply threading the brake, and modulating brake pressure roughly around the threshold by put pressure and out in rhythm. While this method can be used quite efficiently, it is the least preferred way of braking. Any sort of pumping is, in this regard, not recommended.

Pumping will, in theory, make you pass through the threshold a couple of times while braking. However, you will also be braking for quite some time, with too less or too little pressure. In fact, in a real-world scenario, the driver is most likely to hesitate, start off applying too weak a pressure, progressively increase it, and then begin rapid and mindless pumping. The problem with such a procedure is, that is makes the driver come off of the brakes altogether in each "cycle". Additionally, he will not fully utilize the braking potential, and will not reach threshold braking. Moreover, in rapid pumping, doubt whether the driver would even reach deep enough with the pedal. This method is sometimes promoted in slippery conditions, but in these conditions, pumping might not be enough to release the locked-wheels to allow steerability to begin with. In this case, any sort of steering input will not work and will only contribute to a dramatically increased braking distance and less control.

Also, such pumping will not provide better control and will not be useful as a matter of avoidance. This is because weight is being aggressively tossed forward and backwards, and the wheels locking up and releasing (considering that they were locked to begin with or that the driver managed to release them). All of this contributes to an appearance of sharp oversteer in the event of applying even a small steering lock. If you are trying to avoid hitting something, it is most important to begin with hard braking, as this will wipe off speed to enable an evasive maneuver to be done, or to wipe off energy for a possible impact. Any steering in traffic or narrow roadway might mean a sideways collision (which is worst than being rear-ended), and possibly hitting the original obstacle with the tail of the car. While deciding where to steer to, the car is still going ahead. Therefore, pumping which slows you down slowly, will not be efficient in this case, especially since it contributes to panic and the tendency to lock the sight on the object.

Pumping does not save wear on the car and does not help in not being rear-ended. Even a single release and reapply can make the braking distance surprisingly longer. Even of the brakes tend to heat-up or get wet, pumping them is not the best answer.

Note that there is a problem in handling the clutch and gearbox while pumping: Don't declutch and you will stall. De-clutch, however, and the wheels would lock and you might them hard to release. Additionally, if you do manage to release them, keeping the clutch down means you have lost all engine compression, and are running quite quickly during intervals when off of the brakes.

Progressive braking

This method is better than pumping, but not by much, since while squizzing down the brake, you are not fully exploiting the braking potential. A modern brake should be threaded rapidly, but not instantly. In other words, it should not be stomped or squizzed. Again, the progressive approach is more likely to end up in constantly locking up the front tires (with the rear ones still spinning freely), and losing steerability and control. Sometimes, progressive braking is worst than cadence braking!

Hesitation is a typical response of road drivers. In an emergency, they tend to attempt and get out without excessive braking, due to an unjustified fear of lost of control and of being rear-ended. Due to the tender nature of braking on the public roads, drivers tend to start off soft, and then, as they see it is not stopping, they try and increase the pressure. However, due to fear, custom, and the heel on the floor of the car being used as an axle, the drivers tend to increase pressure progressively. This is a tendency that a professional driver in the field of motorsport should overcome.

Regressive braking

This is the most efficient way to use threshold braking. You start off applying the brakes rapidly, almost stomping upon them (though not quite stabbing it) while simultaneously applying pressure with the left foot against the footrest, and then progressively release pressure. Ideally, this should be very smooth. The marking of success are that the car keeps on slowing down in unison, while the driver puts almost full brakes on the beginning of the braking zone, and spends the whole braking zone releasing pressure until reaching the turn-in with a minimal amount of brake pressure. As you are about to reach the turn-in (which might be later than you think!) you need to release even more pressure in order to reach the turn-in with only light brake pressure ("Brake-turning"). Then, declutch and Heel and Toe to downshift into the most appropriate gear to get you through the corner (I.E. Accelerate you out of it).

Don't be afraid if the tires do squeal slightly during threshold braking, it does not necessarily mean that the wheels are locked. It means that a certain percentage of slip is existent, and that is a natural part of threshold braking. In fact, a constant, faint howl should be emitted from the front tires during this procedure. The pedal should be vibrating and the wheel of the car might jerk a bit in the beginning. Make sure that the wheel still feels responsive. However, one of the best signs for a good braking during a race, is that the seatbelt remains equally pressed against your body throughout the entire procedure.

In order to get the feel for threshold braking, the starting racing driver should use several techniques: At first, simply stomp the brakes at once, see how it feels. Do not hesitate and do not keep the heel of the foot on the floor, but rather lift the foot in the air and stomp the pedal at once. Now, try and squizzing down the pedal until you reach the threshold point (the wheel should jerk slightly as you reach it). If it seems to really lock-up, release it altogether and re-apply slightly less hard. Repeat as necessary. Later on, you will be able to brake, release a little bit and then reapply just once. After that, you could curl up your toes to release enough pressure to release locked wheels. Now, you are ready for the real thing: It's quickly brake and slowly release (like steering).

Indications of threshold braking:

- Tire squeal: In theory, a minimal amount of tire squeal, just a feint howl, should indicate good threshold braking. However, if you have a tire with silent elements, like Hoosiers, you are not likely to get as much as audible feedback.
- Steering feel: As the threshold is reached and maintained, the wheel should jerk. If the wheels lock-up, it should feel very light.
- Pedal feel: The pedal should feel more firm and maybe a bit vibrating, the constant release and adjustments are made with the ankle. The pedal should actually squizze back and try to release by itself.
- Seatbelt: This is a sign of smooth regressive braking which can indicate a sustained threshold braking. If the seatbelt remains similarly pressed against your body through the whole procedure, it's a good sign.

The key at first is to apply smooth regressive braking, without locking up the wheels, or locking them up for a moment in the beginning. When you start to use it, don't worry about staying right on the threshold through it. At first, you simply need to get the braking hard at first, and then concentrate on easing up smoothly.

Sometimes, you may hear the rule: "don't brake and turn". This rule has a point to it but is not accurate. First off, the ideal turn is made under light braking pressure, allowing for more weight to be pressed on the front tires. Second, unless pushed to the absolute limit, a road car should be able to handle both applications. Third, even a race car, being pushed to its limit, can handle braking.

The point of this concept is that braking will require some of adhesion on the expense of steering. It can therefore create two problems:

- Oversteer: Will occur under partial or threshold braking while cornering. A forward weight transfer will lift the rear and send it spinning.
- Understeer: Will occur if the front tires are locked. They will not longer have any more traction left for steering and will cause the car to skid forward from the corner. This is practically understeer but is better phrased as lost of steerability mid-corner or "Zero-Steer".

Like with regressive braking, this can be done in either an emergency or as a method for delaying the braking point by braking into corners and through them when entering a corner set, hairpin, tightening bend, chicane, etc... ("Trail braking")

- 1) **In an emergency**, follow these guidelines: First off, start with a moment's worth of maximal brake pressure. This will enable you to slow down quickly with a small amount of understeer, better than uncontrolled oversteer. Then, immediately begin regressive braking. Since adhesion is being divided between both applications, the threshold will be different than on a straight line, and will require less pressure. A good starting point to begin with for the sake of practice is to ease off completely and than reapply moderately hard, about 70%. As the brakes are being applied, undo a nice bit of steering as necessary, as this will enable the car to brake more powerfully and with greater stability.

- 2) **Trail braking**: Complete the majority of your braking in a straight line, and then steer gently and slightly into the corner, easing off of the braking in concordance with the increase of steering angle. In "problematic" moments when you want to stabilize the car, lockup everything for a moment and then returning to normal state of braking.

In both instances, should the back-end indeed step out, you will have to take off almost all of the lock, apply the brakes as hard as possible to lock-up the tires and neutralize the slide, and then easing completely (for beginners) or partially off of the brakes, while reapplying them less hard than you did when the slide began, while starting to apply opposite lock. As the back-end starts to get back into line (and not when it stops to slide), readjust the steering (take the lock off) again. If the slide does not appear to be stopped by opposite lock, apply the brakes as hard as possible for a few moments while straightening the wheel. This will slow you down very quickly and will result in the car sliding sideways towards the edge of the corner, but with its front constantly pointed ahead to the direction where you want to go. Once speed has been scrubbed off, release the brake completely and immediately and maybe accelerate lightly and let the car drag itself through.

Emergency braking

Sometimes, emergencies happen, even on the track. In an emergency, the ability to stop quickly and controllably using threshold braking is important but, unlike when you brake before a corner, here the situation is not planned. One choice is to begin emergency regressive braking. That is, stomp on the brakes (lock-up all tires) and then use regressive braking to unlock them and keep them at the threshold. However, if you panic completely, the other choice is to let the car stop on locked wheels or ABS. Many people, even racing drivers, unjustly fear the brakes, and particularly fear brake lockup. However, locked brakes are a lot better than anything short of threshold braking, even in wet conditions. Furthermore, notice that we mentioned control issues last, because -- unlike the common opinion -- cars braking on four locked wheels should remain controlled and pitched forward. It should stop quickly and under control. Additionally, if you spin or skid out of control, choose this option, as locked wheels might very well pull you back straight to the direction of intended travel. Anyhow, take out steering inputs to maximize braking efficiency and control.

The idea behind this is that, as the wheels lock-up and friction turns static, the wheels will slide over the road in obedience to physical forces acting upon them. With the main force being the car's inertia, a car driving on locked wheels will not sway sideways, because a tremendous force is constantly pushing it straight ahead. Tire issues, car problems (rare in modern cars), road angles/surfaces/imperfections, especially if wet, can create different rates of slippage acting on different wheels. This can make the car less stable, but -- assuming that the driver was swift enough to lockup all four tires -- the inertia will be so large that it will usually keeps the car pitched straightforward. In some wet or split-grip conditions, the car might "rotate" slightly, but around its own axle. Meaning that even if it were to spin all the way around, it would still keep up with its original direction. Normally, however, the amount of rotation will not exceed 50 degrees. It's imperative to not attempt to correct this with counter steering.

As for the clutch, engage it just after the brakes. If you lift both feet in the air simultaneously, you will have hindered leverage on the pedals. By braking and declutching, you remove the resistance of the transmission and engine to the brakes, which usually results in a decreased braking distance, in spite of the lost of engine compression, partially due to the additional fact that the engine injects fuel to avoid stalling completely, again contributing to an increased braking distance without declutching.

Additionally, doing so minimizes the ability of an unskilled driver to aggravate the situation by attempted steering corrections or any other input really. This carries great benefits if the car spins, as the brakes might straighten it up or at least direct the spin in a straight predictable line. The car tends to remain approximately in the right direction, but trays off the central driving line, minimizing the possibility of hitting another road user. If the car does leave the track, it will stop quickly due to the presence of dirt or grass on the shoulder of the track, allowing the locked wheels to dig into it. Additionally, the car will not be vulnerable to a hook spin as it runs out of tarmac.

In this panic stop practice performed at driver's edge, the trainee hesitated to brake hard, which is in fact a common phenomena:

Effects on braking

- **Coefficients of friction**: Surely more slippery surfaces make braking distances longer, particularly in the event of wheel lockup. However, they also make any attempt at threshold or regressive braking very hard. In very rare cases, "pulse braking" (refined "cadence braking") can be helpful, but these cases are rare. Pulse braking is also hard to perform in an emergency. Sometimes, wet or frozen roads can have small differences in grip between different parts of the road surface, but these usually don't carry determinant effects.

  One dramatic effect occurs when braking in this manner over special skidpans, which conceal a line of material as slippery as ice, resulting in extreme split grip (ice is 3 times more slippery than oil!), spinning the car (used in ABS commercials, however the none-ABS always stops in a respectable distance and does not sway sideways, albeit spinning). Tires, tire pressures and dampers also carry a great effect on car stopping distance and stability while braking. Locking the wheels helps on gravel or soft surfaces (like dirt and very rarely fresh snow), because the wheel digs into the surface and builds it up in front of it. This is a great advantage on tracks with dirty runoff areas or in rallying, and is usually more crucial than car stability (which is usually kept intact on the dirt) or steerability. Some tracks, have colored, high-friction materials at the edges of the track (usually a blue and red line, the red having more grip), which are less effective in that regard.

- **Road angles**: Roads with Castor angles (uphill vs. downhill) affect braking distances and roads with camber angles (sideways slopes) can effect stability if braking and locking up wheels. The effect is still relatively minor and should be of any concern when an emergency is due.
- **Perception and reaction times**: In the event of a surprise emergency, the driver would take some time to react. This time is divided into perception time, which is the amount of time necessary to comprehend the situation, and reaction time, during which the body reacts to the situation, until the foot is on the brake pedal. On the road, this time is typically 1.3 seconds. A race driver, being on a different state of mind, can significantly decrease the amount of time until he brakes. It is imperative not to increase this time by hesitating to press down on the brakes or trying to get out without locking up the tires at all or with the steering. Just brake, then decide what to do.
- **Additional tractive demands**: As said, braking and cornering is a hard task, because the amount of available adhesion has to be divided between braking and steering. Not only can this contribute to appearance of understeer and oversteer (braking overrides cornering force), but can also increase braking distances: If you lockup the tires and apply a big amount of steering lock, you can increase the braking distance by a surprising amount, and reduce stability even more.

Avoidance braking

Some people say that it is better to steer around obstacles rather than to brake before them, as one can steer around an object faster than he can stop in front of it. However, this theoretic model is not perfectly fit for reality: First off, this is wrong. The brakes are stronger and the response of the car is more decisive. Additionally one must take consideration of surrounding traffic. It is better to be hit behind (in hard braking), than to be hit in front (in gentle braking) or on the side (if using steering), not even speaking about the difference in chance of impact (a rear-end hit during braking is least likely) and speeds involved. If you do not need a sudden application (I.E. you simply steer slightly and move by one lane) you were not in an emergency.

Drivers will linger over the direction in which they want to steer, according to the limitations of the roadway (rails, lanes, obstacles, surface), and will also tend to fixate on the obstacle they attempt to avoid. As this procedure occurs, the car is still progressing very quickly. Furthermore, even without traffic, and especially in racing, steering to avoid an obstacle is often impossible without wiping off speed and increasing front grip. An evasive maneuver is the most demanding action that can be put on a car, far more than a sharp turn or a fast sweeper. Its best resemble is a sharp chicane being travelled through in a speed higher than that used to tackle a fast curve! By steering, you practically enter a world of endless trouble: You steer to avoid one obstacle but then another obstruction appears or the car skids, requiring an additional steering correction, and possibly a chain of corrections, each decreasing the balance of the car in a pendulum effect.

By Braking hard to begin with, the driver scrubbs off speed quickly, this gives the driver extra precious seconds to decide and react, and makes the evasive maneuver possible by scrubbing off speed, increasing front grip and possibly allowing for the obstacle itself to leave your lane of travel or slow down if heading towards you. At the worst case, braking allows for a far more sympathetic crash, should it indeed occur. Again, it's like approaching a chicane: Wipe off speed before in the braking zone, steer one way and than the other.

Many people resort to cadence braking as an avoidance braking technique. However, this sort of braking carries more danger because it does not slow you down very efficiently, and can hinder steerability due to weight transfers and constant wheel-lockup. It's best to brake hard. Now, either use regressive braking to unlock the tires and keep them at the threshold of locking-up or -- if you panic -- keep them planted. Having scrubbed off a great deal of speed (actually waiting to steer away late!), you will need to release a great deal of braking pressure (though not all of it) and steer. The problem is that the driver tends to fixate with the eyes on the target. The way to overcome this is to shake the whole head sideways, forcing the eyes to follow, and then focus on a visual target in a direction of possible escape.

Correct utilization of the Visual field to begin with will help decrease the chance of "target fixation". Now, use the "bump to bump" steering technique: Keep the hands at 09:15, left foot pressed on rest-pedal, right foot slightly on the brakes, steer quickly but not too much one way, then immediately the same amount the other way, and back straight. Do the whole three steering movements as quickly as possible, ideally lasting for less than a second. You don't need to steer a lot. Even in a road car, less than 180 degrees of steering will do. In fact, if you go off of the pedals, and steer 190 degrees (cross the forearms) one way and than the other, you will move aside by one lane.

If you lock the wheels, a good advice is to immediately turn the wheel very slightly. This way, you can progressively go off of the brakes until the car seems to follow the line in which the steering wheel is pointed. This will help you know when the wheels are spinning again. Do not, however, turn the wheel more while on locked wheels, as this can contribute to a greatly increased braking distance.

Once you evaded the object and straightened the wheel, you may return to your line of travel and continue your race or apply the brakes again.

Split-Grip braking

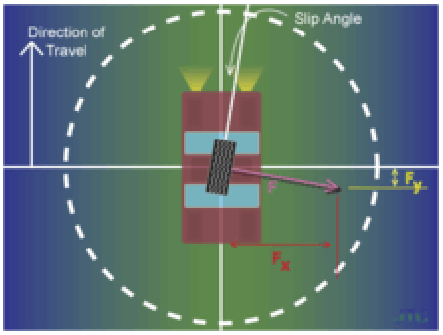
One particular case considered an emergency is when the driver finds himself in a situation of split-grip. This typically means that two wheels (one side of the car) has dropped off of the track or road and unto a gravel or grassy shoulder, with significantly lowered amounts of grip. However, this case is not always so dangerous. One option is to steer out of it: The driver goes smoothly off of the power while using the steering to balance the car and ride it along the shoulder-line with straight steering while braking lightly to wipe off speed, and then steer slightly and gently to board the car back to the road where height differences appear to be small. The car should be let to get back on the road on its own, with a little input and with trail braking. As you resurface, counter steer slightly back towards the shoulder to stabilize the car and immediately straighten while accelerating ahead. If wheels seem to lockup at this case, release the brake and make steering corrections while trailing throttle and dab the accelerator as necessary.

If the need to brake hard on split-grip does occur (which it might), you can try and do threshold braking, if grip is not too significantly different between both surfaces. However, in many split-grip conditions, it's better to lock-up all the tires. This is because trying to achieve threshold braking will be very hard, as the wheels on the more slippery surface will tend to lock-up much sooner. This means that the driver needs to brake very lightly to keep the wheels unlocked, in which case it's better to let the car stop on locked wheels. It might rotate slightly around its own axle, but it normally won't exceed 90 degrees of rotation and, even should it spin, it will continue going straight ahead while spinning.

In this extreme case, one side of the car is on ice, causing a spin. However, notice that the car keeps on going straight.

Friction Circle

The **circle of forces**, **traction circle**, **friction circle**,[or **friction ellipse** is a useful way to think about the dynamic interaction between a vehicle's tire and the road surface. In the diagram below we are looking at the tire from above, so that the road surface lies in the *x*-*y* plane. The vehicle that the tire is attached to is moving in the positive *y* direction.



Circle of Forces

In this example, the vehicle would be cornering to the right (i.e. the positive *x* direction points to the center of the corner). Note that the plane of rotation of the tire is at an angle to the actual direction that the tire is moving (the positive *y* direction). That angle is the slip angle.

A tire can generate horizontal force where it meets the road surface by the mechanism of slip. That force is represented in the diagram by the vector ***F***. Note that in this example ***F*** is perpendicular to the plane of the tire. That is because the tire is rolling freely, with no torque applied to it by the vehicle's brakes or drive train. However, that is not always the case.

The magnitude of ***F*** is limited by the dashed circle, but it can be any combination of the components F_x and F_y that does not exceed the dashed circle.[3] (For a real-world tire, the circle is likely to be closer to an ellipse, with the *y* axis slightly longer than the *x* axis.)

In the example, the tire is generating a component of force in the *x* direction (F_x) which, when transferred to the vehicle's chassis via the suspension system in combination with similar forces from the other tires, will cause the vehicle to turn to the right. Note that there is also a small component of force in the negative *y* direction (F_y). This represents drag that will, if not countered by some other force, cause the vehicle to decelerate. Drag of this kind is an unavoidable consequence of the mechanism of slip, by which the tire generates lateral force.

The diameter of the circle of forces, and therefore the maximum horizontal force that the tire can generate, is affected by many things, including the design of the tire and its condition (age and temperature, for example), the qualities of the road surface, and the vertical load on the tire.

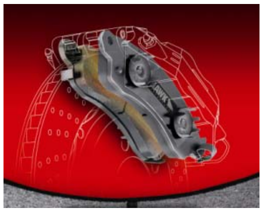
That's a lot of information to digest but can be very helpful to master. Practice makes perfect.

10/10ths MOTORSPORTS

The Black Crack Report

The addiction you don't want to fight

HAWK PERFORMANCE



Did You Know

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