THE MOTOR RACING BOOK

VOL. 1

CAR HANDLING

SUELLIO ALMEIDA

Foreword by Tony Kanaan

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VOLUME 1 - CAR HANDLING

SUELLIO ALMEIDA

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This book is dedicated to everyone who believed, since the early days, that sim racing could be a bridge to real racing.

FOREWORD

by Tony Kanaan

Winner 2013 Indianapolis 500

2004 IndyCar Series Champion

I grew up in Brazil and loved racing with my dad. I remember that every day we would turn on the TV and watch Formula 1 in the morning and IndyCar in the afternoon. I started racing go-karts at the age of eight, thanks to my dad. Unfortunately, he passed away when I was thirteen. The night before his death, we had a really nice conversation. My dad was sick; he had been battling cancer for a while. He asked me to do two things in life: take care of my mom and sister if he wasn't around, and one day win the Indy 500 for him. So I started my journey. I went through many things in my life, even living in a race shop for four years. I had no money, but I finally made it to IndyCar in 1998. In 2013, I won the Indy 500 and dedicated it to him. So hopefully, he'll be proud of his son.

People ask me what's a good quote about racing, and I have to say the best quote I have ever heard was by one of my racing heroes, Ayrton Senna. “If you no longer go for a gap, you are not a racing driver”.

Suellio’s racing skills and driving style fascinate me, as well as how he is always willing to help someone, not hiding any secrets. Throughout my whole career, I have had great teammates who have had great success in IndyCar and Formula 1. We always shared because we always felt like we should “share the secrets and lay it out at the racetrack and see who is the best”. I think Suellio has changed the concept, especially in sim racing, of not sharing things —hiding things— to being honest and saying, “hey, this is the way I do it, and if you learn and become better than me, I guess I have to step up my game”.

His ability, actually, is one thing that people don't understand. It is one thing to have the natural talent to drive and perform. It is an entirely different ballgame to be able to do that and explain the technique. Being a great racecar driver doesn’t always mean you’ll also be a great teacher. Suellio has the great ability of making you understand driving technique to such a high level. I have been racing for 40 years, and I learn something every time that I watch his videos, especially in sim racing —something that I was introduced to very late in my life.

I like the way he creates new concepts to help people because everybody's different. Likewise, I have a different driving style, a different way of learning, and a different technique, and he adapts to that. He looks at you and understands what you need, and boom! He puts it there for you.

Now, Suellio has written a book. I wish I would have had a book explaining advanced racing concepts when I started, when I was eight or nine years old. But back in the day, we didn't have that. And I didn't think there was even anything like it until now.

Now, while you have drivers and coaches and everything, but you have to hire the coach. He needs to go to the track with you and spend a lot of time with you. With a book, you can take the coach with you, read it, go back, mark the important things, come back, and allow it to be a forever learning tool. It is going to make you faster, and it will make you a consistent driver. It is not just the concept of basically having a one-on-one session; you have a book that you can go back to at any time and study. It will make you more confident, and you will probably turn your passion into a profession.

You will see the progress and how quick it is. It is not this way in racing; racing doesn't forgive. You are only as good as your last race. And the quicker you learn, the faster you will be, and the quicker you will grow and reach the top. I consider this book to be a textbook that you can revisit from time to time. You can go to the track to apply what you learn from the book, stop and re-read the book at the same time, and go drive again. So, as long as you understand what the book is saying, it is going to allow you to improve your sharpness and apply new concepts.

I think it is one of the best books, if not the best, I have ever read about how to drive fast. If you want to become a champion, if you intend to be a good race car driver, and if you aim to improve your technique, you need this book.

I'm going to leave you with a phrase that I have repeated my entire life, and it is simple. You will think I am philosophical here. Every day is a new opportunity. Every day, you have a chance to improve. Every day will be better or worse, but it is a new day. I say that every morning. You already have the no. If you don't ask, you will not know if you get the yes.

TESTIMONIALS

“My first lesson with Suellio was brilliant. Probably the most productive and informative training session I've ever had. Suellio's methods are really effective and the observations and corrections to my driving really improved my ability, going down into the tiny details needed to find the extra lap time needed. Everything was explained in a super clear way that's easy to understand and translate into what you feel in the car. I'll definitely be booking a few more!"

— WILL GOULBOURNE, 10 TIME CHAMPION FORMULA 1 ENGINEER FOR RED BULL RACING

“Working with Suellio has been efficient enough for me to be able to become champion in the Logitech McLaren G Challenge in the LATAM region. Also how to mentally approach the races. We must not forget that a coach not only concentrates on the driving technique, but also helps you think clearly before facing a race. Thank you so much, Suellio!"

— GONZALO PEREZ, LOGITECH G CHALLENGE LATAM CHAMPION

“The training is amazing. Suellio is one of the rare drivers who can articulate what makes one go fast and helps you see things differently. He completely changed the way I approach braking and we found almost a whole second during one class alone. In my first race after the session, I was already outbraking people, chasing cars down, and making passes. If you wanna take the next step, Suellio can get you there, no matter your skill level. 10/10”

— FERNANDO MATTOS, SIM RACER

"Suellio's Motor Racing Checklist is excellent. He provides detailed, well-produced, easy to understand information that walks through every aspect of driving on a race track. The quality of the content is really impressive. Suellio's explanations and illustrations are clear and concise, and full of information. He also continues to add new content. I'm rewatching the entire course now, taking notes, and I'm amazed at how much I missed the first time."

— CHRIS GENGARO, SIM RACER

"I've been in Motorsport for 15 years now and have seen a bit of everything, but I have to say Suellio is a talented guy. What really called my attention was his sensibility to car handling, and in how he is able to find what he wants through the setup. It is really impressive, and rare to see people with this level of feeling. Most importantly and relevant, many people know how to execute but cannot teach. Suellio is articulated, extremely intelligent, and keen to share what he knows, making him a person that teaches properly."

— SÉRGIO SETTE CÂMARA, PROFESSIONAL DRIVER,
FORMER FORMULA 2 DRIVER; FORMULA E DRIVER.

ACKNOWLEDGMENTS

This book would not have existed if it wasn't for my fiancée, Amanda. She has been an incredible support in my life and work. She is the one taking me outside to write, to read, and to live, really. Thanks to her incredibly stable, consistent, annoyingly healthy love, I kept going, for over a year, to write this for you. We have grown together every day since the day we met, and we will continue to do so. I would not have even started coaching if I hadn't met her. Her mom, Moema, was the one who gave me the idea of starting to coach as a way to make some money to pay for my university tuition. It happened on a regular day, during a regular chat, and I could have never imagined that it would change my life forever. Thank you, Amanda, and Moema; I love you both!

My parents and my siblings have always given me so much support in whatever crazy decisions I've made in life. They were so supportive that somehow, I felt it was a joke or something. But no. Antônio Carlos, Sueli, Suelton and Suellen would say yes to all my crazy decisions, from quitting engineering, to starting a piano career 2000km away at age 21, or to move to a completely different country and then quit piano after building an entire career to start racing cars. They would just say yes. They are still always there for whatever I need. I love you!

I have spent over two thousand hours with all of you, my students and patrons, in calls, watching you drive, taking notes. Always thinking, coming up with better ways to make you go faster, seeing you fail, then try again and thrive. We share this passion and have created great memories together. I continue to spend over 20 hours a week connecting with you all over the world. Thank you for teaching me so many different English accents! This book is, in so many ways, made by you! I want to personally thank some people who have become my friends and helped me become who I am today.

James Carter is one of you guys. He's one of those students who started when he didn't even know the correct racing line. He would slow down and panic when another competitor got close to him. We've worked together for many great and memorable sessions and since then we've become great friends. His improvement? You would not believe it if you saw him when we first started compared to now. James also supported me when I transitioned to racing in real life and did not have money to buy a new set of tires. He donated a set and helped me conquer my first podium in my first season. I will always be grateful!

Marlon Familton is also one of you. We've been working together for many months and every time we get back together for a coaching session, I realize how far we have come. He is also a writer and helped me review this book. Marlon, your help has been invaluable. Thank you for everything and let's continue to share these moments finding those tenths!

Greg Hoobler is an incredible person. Our conversations about racing technique were always super interesting, and his application of my tips were always on point. Greg improved a lot and we ended up only needing the occasional session to perfect his driving, since he was already flying. Thank you, Greg, for trusting my teaching and always being there for me!

Layton Freitas is an incredibly intelligent and disciplined driver. We did two sessions a week for some good months and the improvement has been insane! We quickly became friends and he is incredibly supportive of my coaching. He is helping me to grow too. I always learn something from him and there is still so much more! I hope that we stay in touch for a long time. Thank you, Layton, for trusting my work and for your great advice in many areas of my life!

A big shoutout to Brian Lockwood, Sam Kuitert and Kane Halliburton. These guys were the most advanced and disciplined Sim Racing team, and all of them have competed in elite championships, against the best of the best of the best. I have learned so much with Brian through amazing discussions on racing technique, always on the edge of the current literature, developing new concepts (he was the one who first gave me the idea for the Exponential Steering concept!) and spending countless hours practicing and polishing our techniques. I'm grateful to have spent so much time with you guys and a big part of my sim racing success is because of you!

Evan Gobdel is one of the most intelligent guys I've ever met. We started working together when he helped develop my mental performance and later on we started working on his driving technique. We then quickly became great friends due to so many great discussions and conversations sprouting from the concepts and technique exercises and countless laps on the simulator! Evan developed his technique immensely and transfered his skills to real life as well. Thank you for everything, Evan, and hope to keep contact for a long time!

Buzz!! Paul Busby is an awesome person. He started as an above average driver. We started working together and he skyrocketed into winning high-level special events against top 0.5% drivers in the world. He exploited our sessions to become a wildly fast racing driver. He quickly became a coach to other drivers on his team. We've become great friends, sharing conversations beyond racing and helping each other become better people. Thank you for the trust, Paul. Love you buddy!

William Goulbourne is an impressive guy. He is a 10-time champion Formula 1 Engineer! Can you imagine being responsible for developing the fastest cars in the pinnacle of motorsports 10 years in a row? It's been a huge honor to coach him in sim racing. The coaching sessions were so easy; we could discuss advanced concepts extensively and he would just get it all and apply it on track right away. Also, thank you so much for giving me the opportunity to visit a Formula 1 garage! It was amazing to meet you in person and I hope this happens again.

Abdulrahman Mahmoud started chatting with me years ago when I was streaming my sim racing endeavors on Twitch. Then, we started doing coaching sessions and became good friends. His support has been there since the beginning, from moderating my Twitch channel to giving me full support and advice in my coaching career. Sometimes I still ask him for help with something and he stays on a call with me for hours. Abdul, I will always be grateful for your friendship and will be here for whatever you need!

Matti Helenius was always online. We would start the stream and it always seemed like he knew exactly when I was going to start driving. He was also a Twitch moderator and is a great person - always positive and supportive with everyone around. Thank you for sharing all these moments with us, Matti!

Cameron Das is an extraordinary person. I have learned so much from him and have yet to learn a lot more. As a professional driver, real life champion, incredible storyteller, and content creator, he's always been my benchmark for this influencer thing. We met in real life and became great friends. It's just incredible how much knowledge this guy has being so much younger than me! I hope we meet more and more and do amazing things for the community. Thanks, man!

Now, if this book looks professional, well organized, and well written, it is because Julia Pama was there. She's an incredible book editor! Her work elevated my book immensely, and more than that, in record-breaking time. We had just two weeks to edit the entire book before the book launch and she accepted the challenge. I'm having a hard time imagining that there would be someone else out there who would do such amazing work. Thank you, Julia! And also thank you Tom Russell, her partner, for clarifying racing technique terms and for being my coach when I started racing in real life! You guys are amazing!

José Luis Altet is a treasure trove of knowledge. Not only did he format this book, but he also gave me invaluable insights and tips about publishing, and all the technical stuff involved. He has also given me so many tips related to business, engineering, and so many other, diverse things that I keep asking myself how he learned so many different things in just one lifetime! Thank you so much for your support and work, and I hope we keep working together!

Matheus Ferreira is one of my best friends from childhood. We grew up together in Brazil, and we spent a lot of time gaming, making music, and hanging out, for 15 years and counting. He is the designer of my website and all my logos, colors, banners, YouTube thumbnails, images for promotions, and the cover of this book! A big part of what you see in my content is made by him. Thank you, Matheus, for growing with me. Let's continue to do so!

Andrew Phantavong from PhanMotion is the reason you guys enjoy my video content so much. We started working together to make the best YouTube videos in 2023. Ever since the first video, I knew I would need him for a long time. Since then, we've been working together, writing scripts, discussing storytelling, recording videos, editing them, analyzing the data and then doing it all again. We spend upwards of 20 hours per week working together. I could not have chosen a better person for this job. He is passionate, has so much energy, and his willingness to continue improving and learning new editing and storytelling techniques guarantee that we will keep getting better – hopefully towards being one of the top of racing content creators someday! Let's keep doing it; I really enjoy working with you and I hope we remain friends for a looong time. Love you, bro!

Matt Adams is a friend and top-level driver. We have worked and practiced together for many years and we improved our driving together while practicing for the Porsche Esports Sprint Challenge Canada 2021 and 2022. Matt also helped me identify improvement points for this book and my coaching business as a whole. Thank you, Matt! Still hoping to share the race track with you someday!

Marc-André Séguin and the team from ApexV2R: thank you for giving me that phone call that changed my life years ago. Trusting a sim racer and offering me the opportunity to race in real life has shaped my career and lifestyle to where it is now, and the snowball effect keeps getting bigger. I consider you my motorsports father and will be forever grateful. Thank you so much!

One of the highlights of 2023 was the opportunity to drive a Formula 4 car thanks to the International Motorsport team. When I received a message with the invitation, it felt weird. It was one of those "too good to be true" moments. But it happened. Eight races later, all I can think is how crazy this year has been for my racing career. Thank you Jonathan, Juan, Paul, Pablo, Pato, Dana, Carlos, and everyone at the InterMS team. You have changed my life more than you can imagine!

Jim Hoey and the team from Logitech G, thank you so much for recognizing and supporting my story! You guys found me on TikTok when I had only eight thousand followers and we have worked together and supported each other since then. Jim, you have no idea how much I learn with you. Each time we get in a call, I get out of it boiling with ideas that I'm afraid I'll forget, so I have to write them all down. I'll always be grateful for your support and advice, and I hope we still make great things together!

Tony Kanaan is the boss. He is the one who gave me incredibly valuable advice in difficult moments and always takes care of his team, his friends and treats them like family. I will always be grateful for your support and it is an honor to know such a legendary racing driver like you and to have become your friend. Let us keep growing together and creating the most positive impact possible on the racing and sim racing communities!

My piano teachers during my Bachelor and Master's Degree had a huge impact on the way I think about technique, which has transferred over to racing technique - not only in my own development as a racing driver, but also as a coach and communicator. Ronal Silveira was my piano teacher at the University of Rio de Janeiro and he taught me invaluable lessons that I have used not only in piano, but in life. I owe a lot to you, Ronal! The massive ideas I've had over these years when it comes to racing technique are in part related to the methods you used to teach me.

Paul Stewart was my piano teacher at the University of Montréal. Unfortunately, due to the COVID pandemic, we did not meet many times, but the few lessons we had were incredibly constructive to my piano technique (and again, I do believe they had an impact in my racing technique and coaching career). Thank you for your amazing insights for piano technique and for life!

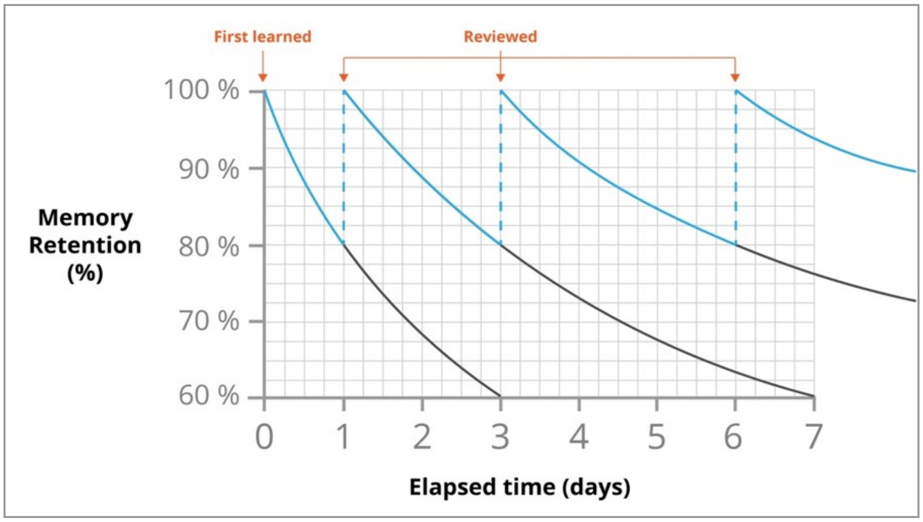
1

INTRODUCTION

Welcome to The Motor Racing Book! In this book, you'll find concepts that will help you perfect your racing technique in the most efficient and rewarding ways. Volume I has been developed to focus on car handling, mostly from a "technique" point of view. The techniques from this book will be applicable both in real life road racing motorsports and in the virtual world (sim racing). Future volumes will explore topics such as racecraft and car setup. In the introduction, we'll discuss some guidelines on how to absorb the most from the book. Writing this book in between simulator practice, coaching sessions, and even at real life racing events has been a great learning experience. Practicing, coaching, and driving, are the times where I reflect the most on the importance of each little detail in the development of our skills.

In this book, you will learn how to identify opportunities to go faster, starting from and working beyond a fundamental level. We will always start with a basic description of each concept, but then explore them to the highest degree possible. You will learn how to maximize deceleration in different types of racecars, how to maximize rotation in corners, and most importantly, how to blend them together, which is where we spend most of the time when driving at the limit. The transition from peak braking towards peak rotation is where the great drivers shine. You will also learn how to find the best lines possible in complicated cornering situations, how different cars take lines differently, and what adjustments to make depending on the type of corner, its characteristics, and its context. The main goal of this book is to give you tools to make sure that you will be on the limit of traction during the entire corner, without leaving even a fraction of a second on the table.

It's okay to skim the entire book on your first readthrough. Let your brain absorb the new terms and concepts just enough to become familiarized with the content. The idea is not to go on track and apply everything at the same time all at once. Try that and you'll be overwhelmed and confused. Driving involves too many skills and we're used to doing it mindlessly, by instinct. If you try to consciously think about all these new concepts at the same time, your system will crash. We need to adjust our instinct layer by layer, building one stage on top of the other.



Ebbinghaus Forgetting Curve

According to the Ebbinghaus Forgetting Curve, [1] memory retention is drastically improved when we are re-exposed to new information several times. Because of that, I have purposely repeated information and concepts in this book with the intention of helping these new concepts sink in, as well as applying them in different contexts.

After you do the first read through, if you want to better internalize the content, read it again carefully, taking notes and practicing on track. Taking notes helps you memorize the most important parts, and it will be much easier for the brain to remember what to focus on when driving.

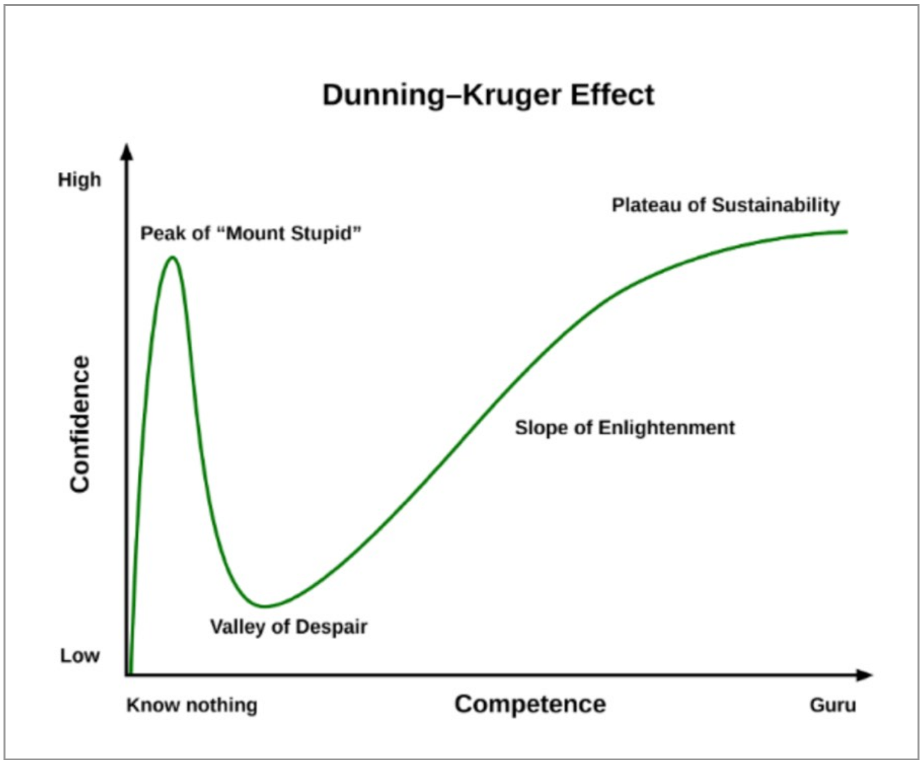
The key here is **transforming knowledge into understanding**.

We will transform a bunch of words, terms, and ideas into physical, muscular feeling that will eventually become automatic in your driving. In other words, once you understand the theory, then understand the feeling, thorough practice and repetition will allow it to happen naturally.

That being said, this process is slow.

Frustration is a necessary part of learning, especially when your brain is still digesting all the new information and trying to fit it into your previous technique and old habits. Don’t fight frustration; embrace it and keep going.

Sleep is an important aspect of this process. Sleep allows your brain to store and process new information into long-term memory. As an example, when I first learned about trail braking, a concept we will explore more later, it was overwhelming to even imagine that someone would be able to release the brakes with such precision – up to the point of braking at 1% of the initial pressure – consistently, lap after lap. After several days of practice with good sleeps in between, I ended up accepting that it is possible. Some weeks later, I was trail braking as if it was nothing special.



The Dunning-Kruger Effect occurs when a person's lack of knowledge and skills in a certain area causes them to overestimate their own competence. By contrast, this effect also causes those who excel in a given area to think the task is simple for everyone, underestimating their relative abilities as well. Don't be fooled by this. Embrace learning and you'll see there's an ocean of things to improve if you want to reach the top. Don't be fooled by your own ego.

Compare. If you really want to see how much you are improving, make a benchmark. Find a combo, a car and track, with fixed conditions in the simulator. Do a stint – maybe 10~20 laps. Record the replay, take notes on your strengths and weaknesses, what corners you struggle with, and so on. Then, start applying all the techniques discussed in this book. After a month or two of practicing, do the same stint with that combo again. Take notes on the differences. **Take notes, take notes, take notes!** Write down your thoughts. You'll be surprised when you read them again after some time has passed; you'll be able to trace your progress much more easily.

Be patient. Expect tiny improvements, then stack them up. Find a tenth, then half a tenth, then one more tenth, then some hundredths. Don't expect to find seconds in a single session, especially if you are already advanced.

The closer we get to the limit of the car, the more diminished returns we see. Take your time and respect your brain and energy. It will come slowly but surely.

When I started coaching and recording video tutorials, I thought I was already a great driver. A year later, I went back and rewatched my videos, only to quickly pinpoint so much to improve in those tutorials. I had no idea at the time. I was almost cringing while watching my own laps from the previous year. Did I notice the improvement during that year? Of course not. The more advanced you are, the more subtle the improvements become, to the point where you don't even notice unless you compare yourself to a long time ago. That's how we master the art of racing. **Slowly**. When trying new techniques, you should even be slower than normal until you can blend the new inputs with everything else you were doing before. Trying to change your entry line just a little bit will snowball into changing your braking release, your throttle application, the balance of the car, etc. This means you need to insist on a new style until it accommodates the rest of your driving skills.

By reading this book, you are learning what I've learned and developed over many years of sim racing, racing in real life, and coaching thousands of drivers in the simulator – including top-tier sim racers, professional racing drivers, F1 engineers, and coaches who teach on and off the simulator. You may read in a few short weeks what I took years of my life to put together. I hope you enjoy this book and open your mind to as much information as possible to help you develop your driving technique. My main mission as a coach is to increase the quality of the racing experience for all my students. I want you to have more fun, to be more confident, and to always keep improving.

Have fun driving on track!

Some Background

Before we dive deep into racing technique, I want to give you some context about who I am and how I got here. I'm a musician; I started learning the piano when I was 11 years old. I have always been a gamer, too. Although I studied engineering for a few years, I decided to go all in and start a piano career. Music has always been a passion of mine and I always searched for ways to learn complicated pieces as fast as I could. But there's a dark side to my musical career. I have never been patient enough to follow my teachers' instructions and notice the warning signs of inefficient practices.

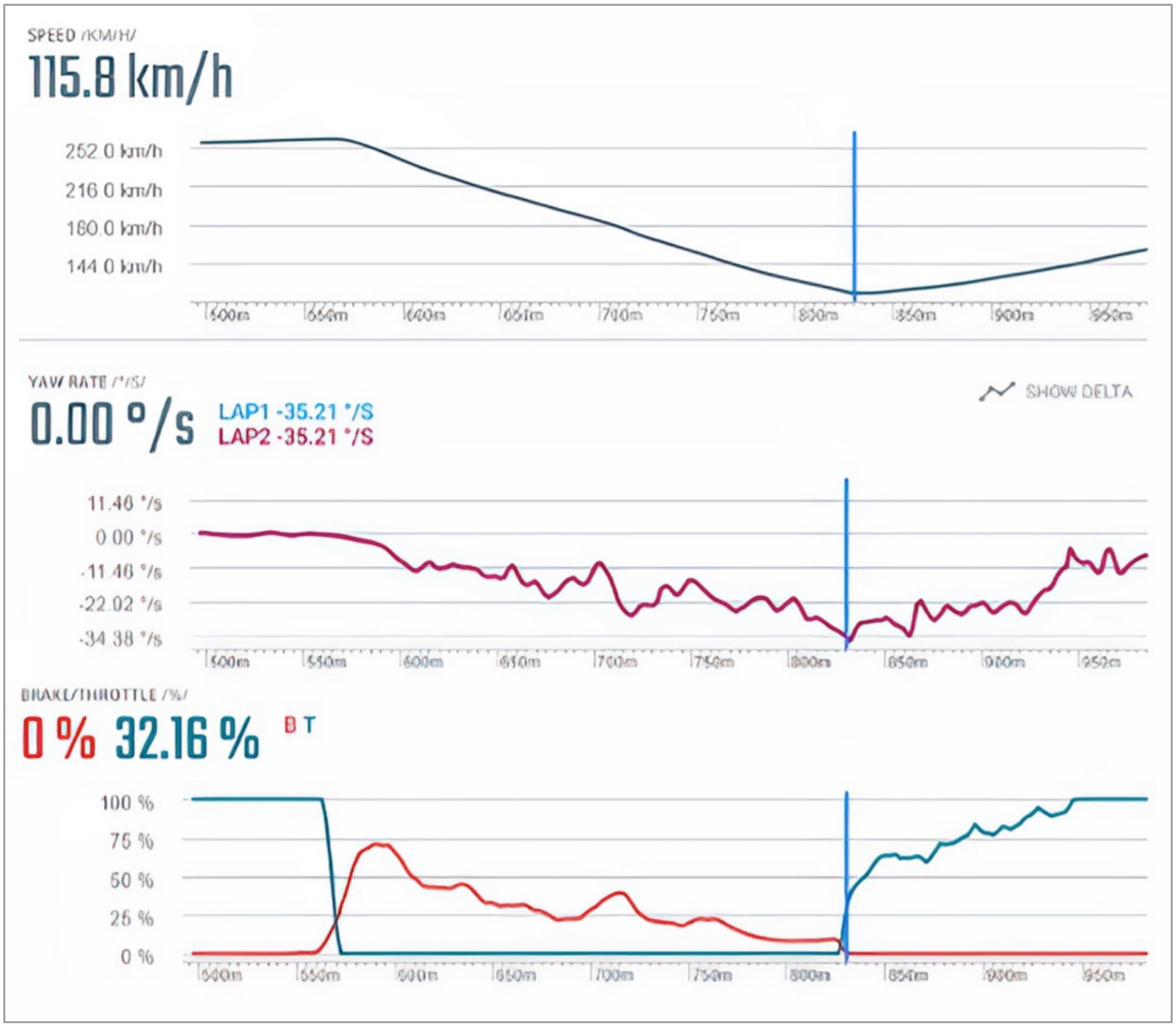
Arts and sports have a lot in common. Mastering complex techniques requires many similar traits across countless domains. In this photo, I am playing the Shostakovich Piano Concerto no.2 with an orchestra.

As a result, I ended up developing many, many **bad habits** along the way. After years of carrying on with this mindset, I started plateauing. I spent so much time in university trying to get rid of these bad habits, while my peers were having less difficulties. By the time I realized this, it was too late. To this day, I still carry many bad habits that I solidified over more than a decade in piano. I solved some of them, but at what cost? Time. A lot of time. Instead of working at higher levels, I had to re-learn techniques at a beginner level. The time and effort I could have spent in school to further improve my piano technique at this higher level is gone.

This realization with the piano and my bad habits happened around the time I was starting to take sim racing as a hobby more seriously. In 2017, I decided to join a Brazilian league in Assetto Corsa, a popular online racing simulator, and I was afraid of developing bad habits in another domain. I began to study racing technique early to start the right way. In 2018, I joined iRacing, a more competitive racing simulation service. The plan was to join another league, a higher level one, where I would compete with the best sim racers in Brazil. I was clearly still traumatized from my bad habits journey in piano, as before driving for the first time in the new simulator service, I picked up a notebook. I started watching onboards and guides about the combo I was going to practice with: the Mazda MX-5 at Okayama. I wrote down everything I learned from each corner of the racetrack – braking zones, gearing, lines – and, when I finally got in the car, I treated it as a real-life session. I tried to understand the car as much as possible and avoid going off track and crashing.

Since then, that mentality has never left me. While I was spending a lot of my time fixing my bad habits in piano, I was building the best habits I possibly could build in sim racing.

I wanted to learn telemetry and understand how that could help my driving. From my coaching experience, I can say most drivers use telemetry wrong. You shouldn't use telemetry to only see what to do, but also to reflect on why other drivers make certain inputs and how you can convert the data into actual feeling on track. I use telemetry mostly for providing evidence while coaching, or to confirm or disprove suspicions about driving habits while practicing with teammates.



In 2019, I decided to start coaching in order to pay my tuition at the University of Montréal, where I would start my master's degree in piano. I never expected that after just a few months of coaching I would gain some recognition. I found it easy to teach others, thanks to my background in music and experience with understanding my piano teachers' teaching techniques. A few years prior, I had tried to teach piano to a friend who played the flute, and at the end of the lesson, she said: "You just gave me way too much information; I can't follow it." That was the first time I had heard that. From then on, I started reflecting on the limits of our brain and how to optimize my own teaching skills.

In 2020, I had already made enough money through coaching to pay my tuition and even some bills, eventually allowing me to stop receiving help from my parents in Brazil. I was in love with how coaching allowed me to connect with many drivers from all over the world and continue to learn. My racing technique also improved drastically, as I was able to break down the driving technique in a much clearer way. Doing so enabled me to teach better and improve my own driving even further.

In 2021, I became Porsche Esports Sprint Challenge Canada Champion in iRacing, which put me in a real Porsche for the first time. Then, a real race team named ApexV2R (Virtual to Reality) put me in a racecar for a test day. In 2022, I raced a real car for the first time in Super Production Challenge in Canada. It was a tough start of the year due to the adaptation from sim racing to real life, the g-Forces, the seating position, the feel of the pedals, and the adrenaline of real-life racing. Shortly after, I progressed towards getting three podiums and a win in my first year. In 2023, International Motorsport invited me to drive a Formula 4 car for a full race weekend, racing for the Formula Inter Championship. I finished on podium on that first weekend. The team invited me to race several times afterwards. On my third race weekend, I achieved my first race win in a Formula 4 series.

I continue to race more and more in real life, having also competed in a 14-hour endurance race at Daytona with World Racing League and many other endurance events. I quit my piano career after finishing my Master's Degree to focus on my racing career. I race and travel to races, I coach, I write, I create racing content, and I create courses.

This book was in the works for over a year and a half. Every small idea I had while coaching, practicing, racing, or talking with experienced drivers became a chapter in this book. Here, you'll have access to many years of hard work, practice, research, and experience. Read this book until the end and I guarantee you'll be a much better driver than you could have imagined.

The following chapters in this introduction are various ideas that will help you set the mood and mindset for this book. These are concepts from different disciplines that will positively affect your skills as a racing driver. In Unit 1, we'll dive into the detailed car handling concepts I've developed over these years of coaching that will help you maximizing grip in absolutely any racecar you drive, virtually or in real life.

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1 The Forgetting Curve, created by Hermann Ebbinghaus, shows how information is lost over time when there is no attempt to retain it, while being exposed to that information again improves memory retention drastically.

2

GENERAL GUIDELINES

Time Distribution: Learning vs Practicing

We often learn things rather slowly. The power of compounding the results of practice takes us to incredible achievements – if we make good use of our time. With the benefits of almost unlimited track time on the simulator, drivers can perfect techniques through repetition and discipline. I have done close to 100,000 laps in my lifetime, and I'm far from the top tier. Professional esports drivers spend up to 35 hours per week practicing. The mindset of perfecting these techniques involves much more driving than learning new things.

We should spend 5% of our time learning new things and the remaining 95% of the time internalizing them into our subconscious driving. In other words, learn something new, then practice until you can do it without even thinking about it. Then, forget it and move onto the next layer. In the end, when racing with others, dealing with traffic, navigating changing track conditions, avoiding incidents, defending, and attacking, you'll be doing all these little things automatically.

Practice is the moment to analyze your technique and bring small details to the surface. You shouldn't work on too many things at once though. Your conscious mind is only capable of isolating one or two factors. So, work on them and then submerge them back into the ocean of skills you collect and develop over the course of your career. That's why you must know which factors should be perfected before others, what bad habits you must avoid, and to always be aware of exactly what you are practicing. Time spent doing blind laps is never a good idea. Winners are constantly looking for the best use of their practice time to improve as much as possible. Join them!

Efficiency

We're efficient when we achieve the best outcome with the least amount of energy spent. An efficient engine will consume less fuel and deliver more power. An efficient driver will reach the best performance with the least amount of tension. This tension can be muscular or mental. Brian Lockwood, a good friend, and coach who drove at top-level world championships in iRacing, always uses the word "efficiency" when working with motorsports technique. I have adopted the term into my own practices of driving and coaching. When looking through the lens of efficiency, we start finding many opportunities to shave off energy spent and simplify driving on the limit.

Driving can be interpreted in an incredibly complex way: with telemetry engineers describing a long list of technical data, slip angle, braking pressures, steering input, etc. But through the eyes of efficiency, the driver is not thinking about all these things at all, especially when in the flow state. Instead, the efficient driver will sense cues and feel the car in a way that allows them to expend the least amount of energy while still reaching near perfection in all ways possible. In other words, just a few efficient cues and ways to drive might naturally trigger a chain of events that follow the path of least resistance and happen simultaneously. Although the engineer might be able to list a series of specific issues, the driver is only thinking about one or two, and the other things happen to be connected.

My point is: you don't have to think about everything, because you won't be able to anyways. No one can. Instead, think about specific inputs or behaviors that might be the root cause of other inputs and states. The fast driver will eventually find the most relaxed state, where thinking only about some things will be enough for them to find the limit.

One would think that a prodigy driver has better innate abilities – that they are "born better." I have a different approach to describing this phenomenon. The prodigy driver is the one who was lucky enough (or was well instructed) to find the most efficient ways to drive since the beginning of their technique development. Some ways to think are just more efficient than others. There are drivers who are capable of driving incredibly well yet cannot describe what they are doing in precise terms. This is because they have found a way to drive that is so internalized and efficient, they didn't even have the time to put words to it. Through the eyes of efficiency, they're doing it "by feel." However, they still probably have some cues to understand the behavior of the car and take it from there, without going through a long and complex thought process.

Being able to describe the things you do is not a bad thing. But if you are over-thinking states (and as a late learner and driving coach, I include myself in this group), you may end up going down a longer path to find the outcome that the natural driver found much earlier. If you are not able to shrink down and simplify these thought processes, you may end up being overwhelmed and failing to find the true efficiency in motorsports: going from point A to point B as fast as possible.

Work smarter, not harder. Mindless effort may not only waste your energy, but also bring you further away from your goal.

Good vs Bad Habits: Muscle Memory

As Ross Bentley said in *Ultimate Speed Secrets*:

> *It is much like the pathway flowing water makes in dirt. The first time the water begins to flow, it seeks out a pathway. The more it flows, the deeper and stronger the pathway becomes. The same is true of the neural pathways in your brain. The more you practice anything, the stronger and deeper the programming becomes.*

This quote describes the way our brain works. We can consciously move our arm up and down if we want, but we can't consciously control a complex set of movements like driving a racecar at speed. You just can't actively think about throttle, braking, shifting, steering, traffic, breathing, blinking, and everything else that is involved in racing. Most of these things will happen at a subconscious level. They happen immediately and automatically. We just need to program them correctly. Muscle memory is not really stored in your muscles (I'm saying that because I thought it was when I was a kid!), it is simply a given movement that has been repeated enough times that your brain has created a strong pathway associated with it.

Muscle memory is the result of conscious repetition. It becomes an automatic reflex that requires less conscious effort to be executed. Muscle memory is important in absolutely everything we do in life. In many ways, you have muscle memory in places you never even thought about. Think about language. You can produce sounds that people from other linguistic backgrounds may not easily reproduce because you have spent your entire life practicing that sound naturally. If you try to speak a new language, you'll find yourself struggling to produce some sounds that you never had to produce before. It can be difficult to learn them because you have no muscle memory! Your tongue never had to roll in that specific way or touch the back of your teeth like that, so it will be a new and uncomfortable thing to do. After a while though, you get used to it – possibly to the point you don't even think about it anymore, just like your native language. This is the way our brain works for a lot of things: language, sports, walking, social skills, emotions. We get used to things and develop more proficiency the more frequently we are exposed to them.

There are two important characteristics of muscle memory of which we need to be aware. The first is that it takes time to build. The second is that it also takes time to deconstruct or change what our muscles are conditioned to do. Muscle memory doesn't only happen in the ways we want to condition ourselves. It happens for everything. A person who learns something the wrong way (through the lens of efficiency) will develop a muscle memory that "protects" itself from being fixed. If a racing driver has a bad habit of pressing the brake pedal with their heel for years and someone tells them to instead brake with the ball of their foot, that person will find the new way extremely uncomfortable. It will feel wrong. The driver will have to spend a lot of time consciously thinking about pressing the brakes in the new way. They would then be unable to drive at the very limit, since a lot of their attention is focused on that specific change in muscle memory for many days or sessions of practice.

Think about how much effort is required to make a simple change in such a simple thing. Think about the time needed to make this correction – time that could have been used in other more specific ways, like finding better lines or understanding the car's balance. This time would be spared if the driver had started their driving career with proper instruction and learned how to position their foot correctly from the beginning. Time is the most important resource available to us. And it will always run the same, for you or for your competitors, so using it efficiently is always a good idea.

Driving is an incredibly complex sport. Try to think about how many bad habits can be developed. Infinite! If you don't look for the most efficient ways of doing things in your technique, you open the door and let all the bad habit demons get in. You might only know what you are doing wrong and reinforcing when someone else points it out, or when you do a strong self-analysis. While figuring it out yourself is possible, we're talking about time efficiency, so it's always better to look for instruction.

Changing habits is always going to be outside of your comfort zone. It feels weird to try to change something you've been doing a certain way for years, and most likely there will be a built-in defense against change. You may defend your driving as your "style" and "just how it is," but even if you do open your mind and try different things, it will take some time. It's important to be aware of how difficult it is to learn new things, so remember to save some mental energy for them when practicing. But try them. Muscle memory is dumb. It will always want to stick to what it knows. The conscious mind can give orders to that muscle memory to slowly change it.

Let's imagine two ways of driving. Method A is efficient, allows you to drive without too much effort, and you can become a great racing driver. Method B is only slightly different, but it prevents you from trail braking correctly (maybe the habit of releasing the brakes too quickly mid-corner), causing the car to understeer. Both examples are reinforced through years of practice and racing. A driver using method B might have learned skills on top of their habit to compensate the understeer and find some lap time. Driver B also changed the setup of the car to compensate for the understeer and now feels like they are on the limit. A driver using method A, however, can get in cars that naturally oversteer or understeer and adapt with no problem, since they are capable of trail braking and can change the speed of brake release to determine the balance of the car. Driver A does not worry too much about setup for balance, focusing instead on setup for pure lap time and other subtleties.

Note that I said Driver B built a pile of habits on top of their bad habit to compensate its effects. You can build a series of habits, layering them one on top of the other, but if one of them is wrong, the others will be affected. Then, you amass a collection of skills that are all contaminated by something you built early in your career that was not ideal through the eyes of efficiency. To correct that, you would have to change a little bit of every single habit that was built on top of the bad habit. Again, that is time lost.

Of course, there are some factors we can't control, like what we have been taught before we were aware of bad habits. Promise me that after reading this chapter, you'll think about it and be careful about what you learn next, who teaches you, and how you can identify your current bad habits. Then, get rid of them so you can make better use of your time from now on.

Key Accelerators and Enemies of Technique Development

It's possible to put in an hour of practice and get better. It's also possible to put in the same amount of time, but by making a few adjustments to your practice methods, to double the amount of improvement. In this chapter, we'll highlight a few important tips so we can know exactly what to aim for during practice.

Key Accelerator #1 Awareness

If you know what you are trying, you can adjust it. If you know what caused a problem, you can adjust it. Control is directly related to knowing exactly what is happening. The worst thing during practice is to lose control of the car and not know why.

One of the most effective ways to develop driving technique that I use with most of my students, from beginners to professional competitors, is to make them induce the mistake they're trying to avoid.

If you can cause it on purpose, you know how to prevent it.

Are you afraid of oversteering? Okay, then spend a few laps oversteering *on purpose*. This way, we become *aware* of how to use our driving inputs to cause the oversteer. Although we will still spin sometimes, we'll eventually learn how to manage the oversteer and stay on the limit for longer.

If you are unaware of what you are doing, you'll be afraid of making mistakes, but they'll happen anyway and make you feel terrible. That will make you develop a Hesitant Technique.

Technique Enemy #1 Hesitation

Hesitation and fear walk together. When this mental state takes over, learning is drastically impaired.

Fear inhibits learning

Hesitation shows up when we're afraid something unpredictable will happen. Unpredictability comes from being unaware of all the dynamics in racecar driving. One of the great benefits of sim racing is that we can spin and crash as much as we want, so it's an awesome tool for us to try absurd driving styles and test the limits of the car. Using simulators, we can fight back against hesitation by deliberately causing what we're afraid of. This works like magic. Within just one coaching session, some of my students were able to go from being afraid of oversteer to fully controlling it and maintaining nice slides just to show off!

Key Accelerator #2 Getting the Right Information In

Although this is listed second, it doesn't mean it's less important than awareness. Generations of drivers have tried different methods and driving styles, documenting it all for us. All you need to do is get the right information and work on it on track. In this book you'll find my contribution to racing technique's literature, with many new concepts to help drivers find the limits in a much more efficient way. Your job is to make sure no information goes unnoticed or ignored so you can build the best technical vocabulary possible. The more you know about racing technique, the more you can work on being *aware* of all these things while driving. You'll eventually get to a point where you apply all of it without even thinking about it.

Technique Enemy #2 Passive Driving

There should be no waiting if you are driving on the limit. Passive driving happens when you are waiting for the car to rotate on its own during the corner. There's a full chapter on passive versus active driving later in this book, explained in a more technical way, but I will cover it briefly here.

Passive driving is generally related to understeer. When you find yourself waiting for things to happen to you mid-corner, you are not on the limit. An active driver is constantly adjusting their driving – from initial braking all the way to the exit of the corner, with the car floating on the verge of sliding. Some drivers are afraid of oversteer. They end up being under the limit or preferring understeer instead, which are driving styles associated with passive driving.

Posture

It sucks not being comfortable while driving. Being uncomfortable sucks up all your energy and concentration. Comfortability is a prerequisite to getting in the flow state and driving fast. A good posture through the lens of efficiency allows the driver to spend the least effort possible to steer, brake, and withstand the g-forces of a car. It will also prevent injuries in the long term.

A perfect posture is one that is not even noticeable to the driver. It will allow you to drive for hours with no unnecessary soreness or pain. It is also imperative in seamless communication with the car.

One of the most sensitive parts of driving is feeling input from the steering wheel. The Light Hands Technique, which will be discussed in Unit 3, requires total relaxation of the body to be fully realized. Let's use sound as an analogy.

Imagine the feedback from the steering wheel at the most subtle and advanced levels. Think of it as a friend who doesn't speak loudly. It is someone who whispers when talking to you, no matter how much you ask them to speak louder. Imagine that you are at a heavy metal concert with this friend. How many of their words will you be able to understand? Don't even try! But if you go to a nice quiet library instead, you'll be able to have the conversation.

For this analogy, your body tension and comfort are the ambient noise. An uncomfortable posture with lots of tension and distractions is the metal concert. You just won't have enough headroom for the details. A perfect posture is one that, again, is not even noticeable. You are relaxed, nothing hurts, and you can focus on the small stuff. This is the library.

Another way to see this is reflecting on the idea of *becoming One with the car***.** This is the dream of any racing driver. The technique reaches its peak when the boundaries between the driver and the racecar cease to exist. The driver and the car are the same thing, as if you could feel the tires, the steering wheel, the brakes, and the engine, as extensions of your body. This is only achievable through great communication – and relaxation and comfort are key in developing the physical ease to have a conversation with the car.

Pedals

When setting the pedal distance, make sure your leg is almost straight when the brake pedal is fully depressed. You still want your knee to be a little bent, though. This is especially important if the car has brakes that require a lot of force. Pressing the pedal too hard with the leg too bent will hurt your knee in the long term, while pressing the pedal with an overextended knee can similarly injure it. It's also important to make sure the leg is in line with the pedal. I remember having set up the brake pedal on my simulator just a little too far to the right and feeling a lot of pain in my knee until I finally noticed the issue. After aligning the brake pedal properly with my left leg, the pain was gone.

I use 85kg of brake resistance. For reference, F1 drivers brake with up to more than 100kg. Production-based cars with unmodified brakes will be much lighter, with ABS kicking in around 30kg, on average. The heavier the brake pedal, the more important setting your pedal alignment will be. If you are braking with a soft pedal where you can easily reach max braking pressures, it’s okay to bend your knee more. This applies especially to drivers who use a gaming chair and desktop as a racing simulation rig and can’t decrease the angle further.

Braking vs Seat

If your seat wasn’t attached to your simulator or car, braking would immediately move it backwards. That is because the same force applied to the brakes is applied backwards to your seat. Meaning 50kg applied to the brake pedal is 50kg of pressure against your seat. It is possible to feel that pressure in your back. You can improve your hard braking precision by paying attention to how much your back is pressed against the seat. Make sure that the pressure is mostly concentrated in your lower back. Your contact point to the brakes should be the ball of your foot. That is where the pressure will be applied. When braking, the energy should be concentrated on these two areas only!

Tip: In simulators, the pressure that the pedal reads will depend on how far from the pivot of the pedal you are pressing, as the leverage is different over the surface of the pedal. If the pedal is not inverted, pressing on the lower end of the pedal will actually make it more difficult to reach full pressure. By moving the ball of your foot up and pressing closer to the upper edge of the pedal, you’ll most likely hit the maximum pressure with around 10-20% less force. Here are a few other related tips:

1. Make sure you are always pressing the same area of your brake pedal for better precision.
2. Be careful not to tense your toe up too much.

3. Your heel should be free to move up a little bit when pressure is being applied. If it's stuck to the floor, energy is being lost and you are losing precision and efficiency. If you have a tendency of keeping your heel glued to the floor while braking hard, you are probably not feeling the energy reaching your back and the seat properly.
4. Your lower back always needs to be touching the seat. That's where your core stability comes from, both for turning and braking.
5. For the throttle pedal, since there's generally much less resistance, your heel will most likely remain rested on the floor when accelerating. The energy should flow freely from the ball of your foot to your back, passing through the heel and the knee without being stuck there. This is incredibly important!
6. Precision comes from efficiency in brake force application. The Press Less Technique allows you to release the pressure seamlessly and smoothly. This requires good braking posture.

Steering Wheel

When holding the steering wheel, you should always use the 9-3 position. This is the most stable position as you'll spend energy more efficiently when moving the steering wheel around. Never do 10-2. Your hands must be as far away as possible from one another. This gives you the best stability for fast-moving actions like countersteering. When you turn the steering wheel, one hand will be pulling down while the other will be pushing up. Still, try to even out the energy spent by both hands. If you are driving karts, you can push much more with the outside hand (the right hand if you are turning left, or the left hand if you are turning right), because of the wheel construction. Pulling the wheel down with your thumb in karts causes pain and soreness very quickly. In fact, pulling the wheel down with your thumb can cause a lot of pain in your hands in any car. Make sure you are not gripping the wheel too hard with your thumbs. Use just enough energy to hold it and move its angle – no more than that.

Every little detail counts. Add them up and your better form will allow you to drive for longer sessions without getting hurt or becoming too tired. This will ultimately make you faster. If you can practice for longer or be more comfortable during your sessions, you'll let more information sink in, you'll be freer to try new things in your technique, and you'll improve faster.

Tension and bad posture are some of the most underrated problems that will prevent you from being a winning racing driver. Most people won't give the importance to them that they deserve. It is by shaping and treating your biological machine well that you'll be able to master the racing machine.

The Ego Barrier

To think you are good is useless for your improvement. Mentally, you want to think you always have the potential to improve. Be open for further improvement! You want to try to go faster, to perfect your lines a little bit more each lap, to feel increasingly connected with the car, to be always looking forward. When you think you are good, that is a static mindset. It stops your improvement right there. Of course, you can think both: "I'm good, and I want to be even better."

We often conflate good drivers with high egos, but ego has no practical use in high performance driving. This is because thinking about oneself takes up brain real estate. As discussed before, our conscious mind does not contain a lot of working space, so anything that is happening in our mind that is not about feeling and driving the car is taking away space that should have been purely focused on those two aspects.

The flow state does not contain any notion of self. As per its nomenclature, it flows with the technique as if the driving is happening by itself, not caused by the driver. The car drives the driver. The driver is just witnessing the event, as their subconscious, well-programmed mind takes care of the inputs.

Have you ever been in a situation where everything is going well – you are leading a race on the last lap – and then suddenly you start thinking about yourself, the reaction of the team, your interviews, and all the glory that comes with a victory, and end up losing concentration and making mistakes? This is the ego taking control and shutting down the flow state.

As you try to consciously take control of your driving, it becomes sloppy. One of the biggest challenges for athletes is to let themselves go and *become* the sport, without fighting against their ego.

How can we get rid of our ego? I have some tips for you to act as a starting point, but don't just trust me. Do your own research or consult a sports psychologist to see what will work best for you.

Don't try to block thoughts.

Try to distract yourself with the right ones.

If I tell you to not think about a chicken crossing the road, you will obviously think about it. Whenever something is mentioned, you'll think about it; you'll imagine it.

Imagine a canvas painted white. Nothing else, just white. Now imagine someone painting it pink. Now blue. Now let's add some difficulty. Do not think of it as red. Let's say red is bad. Have you already thought of it as red, even if just for a fraction of a second? Most likely. To not think of red, it's easier to go back to thinking of the other colors. Think about blue. Now green. Close your eyes for a bit and keep your green canvas in mind. Think about your breathing while you calmly imagine the green canvas in front of you. Do this before you keep reading.

Difficult, right? It seems like the thoughts start fighting with each other and the more we try to take control, the worse it gets. Some people will be able to concentrate on the green more easily, but others will struggle with the red canvas coming back all the time. This is a simple analogy that gives us an idea of how difficult it is to *not* think about something. Since our ego is a very strong part of our mind, it is a real challenge to get rid of it. But just like thinking of the other colors, the secret to dismissing your ego is to distract yourself with the right things. This could even be the experience of driving.

When a child plays with toys or starts a sport at an early age, they don't really think about themselves too much. They're easily distracted and entertained. This distraction and entertainment, or experience, is one way to keep your mind focused on the right things. Don't try to block thoughts.

Instead, try to distract yourself with other ones. When the egotistical thoughts come back, don't fight them either. Let them be there, acknowledge them, and move on. If you think "Oh no, I'm being distracted by my own ego, I'm losing focus!" and panic, these thoughts will stay for longer. Let them flow. In and out. Don't give them any importance. Then, they'll slowly fade away.

I'm really talking about the conscious egotistical thoughts. This does not mean you won't get nervous, or that you won't get the rush of adrenaline and focus when necessary. Those will always happen in motorsport, but their presence is good. Adrenaline will enhance your reflexes and you'll drive even better. Welcome these sensations. They overclock your body so that it uses more energy when it's necessary, like during the race. You'll get tired more quickly, of course, but this is how cool our body is. We naturally activate a "boost mode" and improve our performance when needed. Then we calm down and start saving up for the next one.

When you meditate, you try to either focus on a single thought (convergent meditation) or you open your mind to any thought (divergent meditation). In both modes you are calmly focusing on something, never blocking other things. The mere attempt to block other thoughts is already thinking about them, so it won't really work.

> ***The real fun in life is in the process of doing things, not in the final results.***

It may be funny to think about, but the losers of a race are often thinking more about winning than the actual winners. This is because the winners are busy with other things. They're thinking about driving, they're thinking about improving, and most of them are enjoying the moment. Of course, it's not always like that, but the general lesson from this is that if you enjoy the process of improving, pursuing the limit, and driving, your performance tends to improve. When you enjoy the process of learning, that becomes part of your routine, and you don't want it to end. If you win a race and get too comfortable, you'll end up improving less quickly afterwards.

Don't get me wrong, I'm not saying you should not celebrate victories or take your time to relax and recharge. But as soon as you get back to preparing for the next race, go back to being 100% focused on improving even further. Don't let past victories make you comfortable; try to make them motivate you even more. The victory is in the preparation. And the preparation must be lived in totality. Be present and focused during practice just as much as you would be in a race for the title of a championship. That race will be a result of how well you prepared throughout the year.

Chasing Discomfort

When working out or practicing hard, athletes often need to deal with discomfort, physical or mental. It's just the way it is. Chasing discomfort requires a high amount of energy and motivation that is not always going to be there.

Waking up early and taking a cold shower is famously effective as a small reminder that we actually feel better after discomfort, yet we fight back against doing it again the next morning. The physical discomfort of the cold water generates some energy and wakes us up, but it doesn't end there. It also serves as a reference for our mental discomfort and prepares us to deal with other forms of stress.

You must enjoy stress. Enjoy working out, enjoy running against your limits, and enjoy being outside of your comfort zone. Enjoy being moved into action and moving others. Being a racecar driver may require less physical preparation than some other sports, but you still need to be at your best form to perform better. Physical and mental performance are always tied together.

To wrap up the ego chapter, I just want to emphasize that this is a very superficial introduction to the domain. There are full books with hundreds of pages about general peak performance that go much more in depth that you should read. I strongly recommend *The Art of The Impossible* by Steven Kotler. The author spent his entire life following high-performance athletes from many domains, studying the psychology and neurology behind peak performance in detail. By reading his book, you'll learn what he spent at least 15 years developing and researching.

Fitness: Mind and Body on the Limit

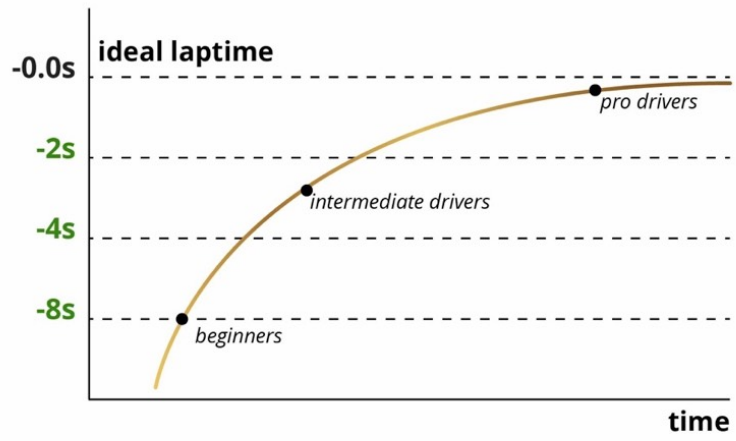
A healthy mind needs a healthy body. Michael Schumacher, former German Formula 1 driver, was one of the first drivers to exploit this concept to the extreme. To him, “fitness equals lap time.” By becoming an incredibly fit driver, he found he could maintain his focus for longer while also keeping his energy up during long races.

There are no downsides to exercising. Working out is one of the few things in life you’ll never regret doing. Among its numerous benefits, racing drivers should note an improvement in focus quality and duration.

By realizing that there is this intense connection between mind and body, a determined racing driver will make an effort to keep both sharp. To harvest the best mental benefits from working out, focus on high-intensity sports that will increase your heart rate. Cardio exercises like running, swimming, or cycling are going to give you more benefits in racing than weightlifting, for example. Enduring through tiredness is what will give you the edge. Keeping up with a healthy exercise routine will spill over to your other habits, like what you eat or how you sleep. You’ll see that you need to sleep better and eat better to keep up with the energy and motivation to exercise, and the exercise will help keep you motivated to sleep better and eat better. It’s the best vicious circle in life.

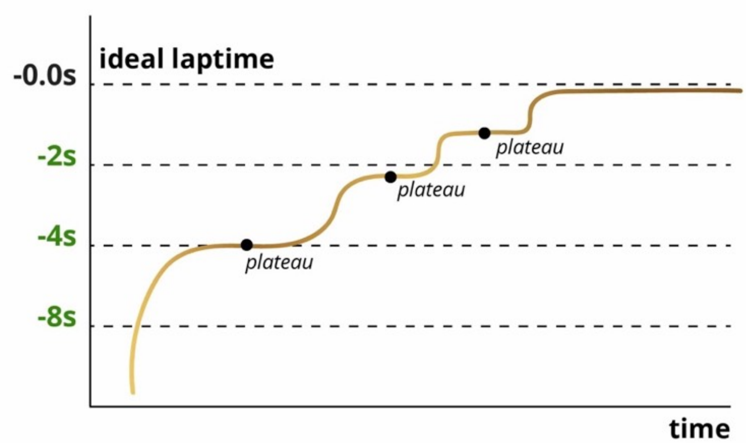
Small Changes: You +1%

Driving technique improves incrementally. As beginners, we improve by gaining big chunks of lap time. Since we’re still learning the basics, we end up gaining full seconds in single sessions. As we progress, we start seeing diminished returns, and the gains in terms of lap time are progressively smaller, down to just a few tenths in a whole day. Still, we can make huge gains over time if we are patient and focused on the progress, the learning, and the discomfort, as a routine.



As beginners, our lap times can improve drastically since we're still far from the limit. The closer to perfection we get, the more diminished returns we'll see. Although true perfection is unreachable, the best racing driver is the one who is closest to it.

The racing driver's worst nightmare is the **plateau**. This happens when we reach a point in technique where we fail to improve further, whether that is because we try the same thing expecting different results, because we don't know what else to try, or because we have developed bad habits.



No matter the cause, plateauing means you have stopped improving. The only way out is to learn something new, look for new information, and/or ask for someone to watch your driving so you can find ways to improve your lap times again.

Consider a track with 10 corners. If you manage to find 0.05s in each corner, that adds up to half a second per lap, which in some series might be the difference between P1 and P20.

Even for beginners, understanding a technique and feeling it just right, in a way that gives you a slight advantage in lap times, is a victory. Don't expect to improve magically. The best gains are a combination of thousands of micro-gains over the course of hours and hours of practice. Be patient.

Testing New Techniques

When learning a new technique, allow yourself to exaggerate its application in a way that lets you clearly feel the reaction of the car and what you are doing different. This approach will make you slower initially, as you will be focusing on the big difference in car behavior, which will put everything else out of place.

Racecar driving always involves many different techniques and inputs in combination, simultaneously. When you experiment with something different while trail braking, for example, other inputs might need to be adjusted to accommodate the new technique. Because of this, the first moments of learning something new might even feel wrong – as if it's not the right move. But after some time and polishing, everything comes back into place and the real results start showing up, whether good or bad. To make sure you are really testing a new technique properly, you need to make sure that:

- You are feeling the difference in your own inputs and feeling a different reaction from the car.

This is where exaggerating the inputs at first helps. If it's too subtle, the difference is not clear enough. After a bit, you can start backing off to a more subtle change, always paying attention to the reaction of the car.

- You are testing it long enough to allow your other inputs to adjust to the change.

Most changes will feel wrong at first. Some will stay wrong, which means they didn't work, but some will start making sense, allowing you to extract better results. Take your time.

MODULE I

BEFORE THE CORNER

1

VISION

Vision is the most underrated skill you'll work on, but the one that will make absolutely everything else more doable. It's the most important chunk of information you'll give to your brain to process before making decisions.

With **bad** vision, you will:

- Lose braking precision,
- Get completely lost when battling for position, especially if you are on the inside towards the next corner, off the racing line,
- Have too much variance in your turn-in points, generally turning in too late, and upon noticing that it's too late, turning in too quickly and unsettling the car, and
- Spend a lot of energy inefficiently, increasing anxiety and stress, and getting tired very early.

With **good** vision, you will:

- Make decisions in advance, generally half a second to one second before the actual inputs,
- Open up your effective field of view, absorbing a lot more information like bumps, curbs, dirt, elevation changes, trackside objects like trees, and everything else that can add to your complete mastery of the track,
- Make better decisions when battling for position, especially when off line, since you'll have enough time to make alternate plans based on the opponent's moves,
- Be incredibly more consistent, and
- Be more confident, have more fun, experience less stress, and enjoy your life.

I'm not kidding. Vision is incredibly useful, and you need to train your eyes to be efficient in gathering information that you'll use while driving.

Vision can be divided into two types:

Planning Vision

Planning vision is the popular "look ahead" technique that you will probably hear often. The advice generally stops there: look forward and you'll have more information for your brain to digest and everything will naturally become easier.

There's more to it, though. You don't want to look too far ahead. You should look no more than one second ahead of the car. It's useless to be looking at the end of a hill way up ahead on the track if you are still setting up the line far before that. So, look further, but **not too far**. The visual information coming in must be *useful*.

Planning vision is not enough, though. Things don't always go as planned and we have to make adjustments all the time based on where the car is at that moment, which leads to the second type of vision.

Assessment Vision

Assessment vision is a quick look to check where your car is located – a quick glimpse right in front of your bumper to see where the car *is*. Are you on top of the curb like you wanted? Is the inside tire on the white line where there's a little bit more camber that gives you more rotation?

This doesn't take too much time. All you need is a tenth of a second to check, then return to planning vision.

You want to plan, then check, then plan, then check. I do this several times in a single sector, with my eyes going back and forth between planning and assessing, to make sure I'm keeping the car on the right line. This is *incredibly* important in compound corners, where a little change on the exit of one corner will mean a big change on the entry of the next one!

What about blind corners? Well, it's useless to look forward and plan what you can't see. In those cases, you'll look as far as you can see; in some instances, you'll have to look at the entry curb until the last moment and use assessment vision a lot more before turning into the corner. You'll use the positioning and angle of the car in relation to the curb you are on and use it to time your turn-in. When checking whether it worked, you'll make further adjustments on the next lap. Just don't try to look further when there's nothing to look at.

Train your eyes. Think about these two concepts while driving. It's going to be uncomfortable at first, but then your subconscious will learn the pattern and do it for you. Although it looks easy, as soon as you go back to autopilot mode and start trying to go fast, your bad habit of looking too closely ahead of the car will come back right away. That's why you need to actively think about vision (and nothing else!) for a few laps or sessions to be able to improve your technique to a point where you don't have to think about it anymore.

2

WHAT IS THE BRAKING CAPABILITY OF THE CAR?

To safely find the limit around the racetrack, we need to know not only how much the car can rotate at different speeds, but also how quickly the car can decelerate to those speeds. In this chapter, we'll discuss the braking capability of the car in a straight line, removing turning from the equation to analyze the braking dynamics of a racecar more closely.

It is very common to excessively focus on corners and not optimize the braking phase, leaving a lot of grip on the table. The reason is the method we use to find speed. The most common method for racing drivers is to try braking later first, and then trying to deal with that situation by adding more brakes and trying to keep the car on track. This can be dangerous, since they may end up over the limit, and as soon as they start locking the brakes or using ABS and finding the limit, the chances of going off the track or crashing increase drastically. Then, after having some scary moments, they again become afraid of braking later, and their braking efficiency is harmed. But we don't need to take extremely high risks to reach maximum braking efficiency. We don't need to brake late first and then try our luck to keep the car on track.

Instead, what we can do is brake at the same safe reference, but harder. This way, we won’t be panicking about whether the car will stop, leaving us with more mental energy to analyze and feel the braking performance. **Fear blocks learning**. After feeling that the car can stop more and getting close to the longitudinal limit of the grip, we can start braking later. This is especially important in real life, for obvious reasons, but in the simulator, you'll find the limit of the car much more quickly, decreasing the time it takes to get up to pace. Crashing on the simulator doesn't harm you physically, but going back to the pits and re-starting all the time totally kills the flow of the practice. In other words, we want to find the limit of braking first, in a safe environment/situation (braking quite early), and then we can start moving the braking references further.

Racecars rely on the contact patch between the tires and the track to move around. The higher the force between the tires and the track, the more grip is available to alter the state of the car. If an identical copy of a racetrack was on the moon, the same car with the same tires would have a lot less grip, since the weaker gravity wouldn't be able to pull the car as much, decreasing cornering, braking, and accelerating capabilities. We'll divide the available grip into two types.

Mechanical Grip

Mechanical grip is purely the weight of the car being thrown around the track. On a flat surface, it remains pretty consistent. On tracks with elevation changes or alterations in camber, the mechanical grip is going to be dramatically affected.

Aerodynamic Grip

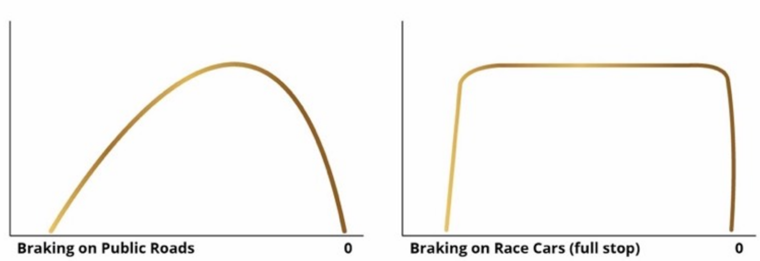
When at high speeds, air collides with the car, interacting with the body in many ways, depending on its characteristics. It can create lift (like an airplane), drag (slowing down the car), or downforce (sucking the car onto the track). A lot of downforce is created on a high-performance racecar, pushing it down and strengthening its interaction with the track. What's amazing about downforce is that the car has a lot more contact with the track, as if it was more massive, but without the inertia that would come with actual extra weight, maintaining its agility. A 1000kg car with 1000kg of downforce produces the equivalent compression at the tire contact patch as 2000kg. When turning, braking, or accelerating, the inertia only applies to the actual mass of the car, 1000kg. If you get a car that has more downforce than its own weight, it would theoretically be able to drive upside down in a tunnel without falling. Don’t try this at home, of course.

3

BRAKING FROM A STRAIGHT LINE TO A FULL STOP

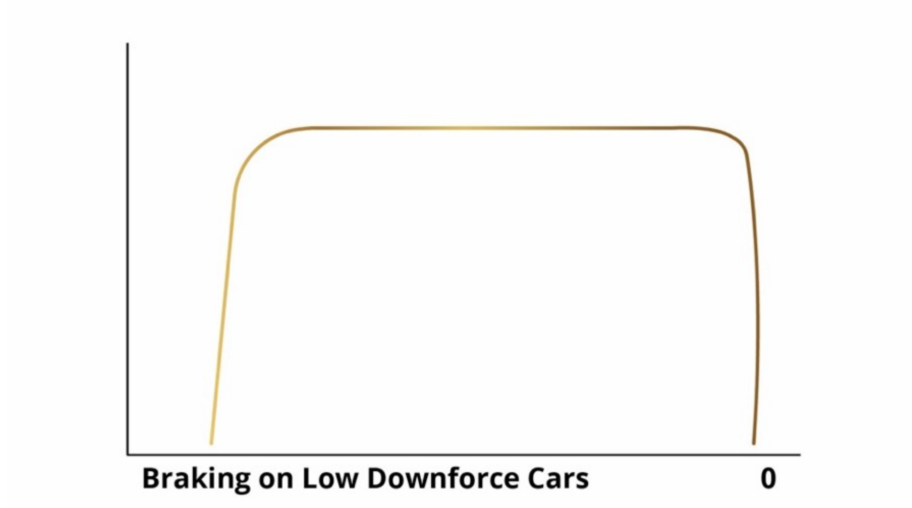
On public roads, we brake smoothly and progressively. The reason is safety and convenience. By squeezing the brakes very slowly, your car doesn't suddenly stop, and you maintain predictability around other cars. Also, you don't want to launch your stuff forward and spill your coffee everywhere.

In high-performance driving, we need to completely invert this approach, and focus solely on stopping the car as quickly as possible, going immediately to the limit of the grip. If we were to do an exercise trying to go from top speed to a complete stop, this is how the telemetry graph of pressure versus speed would look in a racecar compared to regular urban driving.

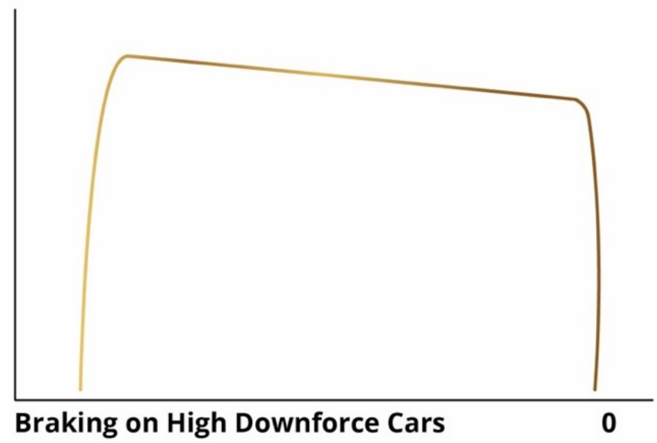


In the example above, you can see that the peak (or highest) pressure is also the terminal pressure (final braking pressure where the car comes to a full stop without locking). This means we could maintain that same braking force until the car comes to a full stop, without locking the tires. This would be the graph of a low downforce racecar, where the influence of the air colliding with it is low, and where we rely on a consistent mechanical grip. These examples are on a flat track with no elevation changes.

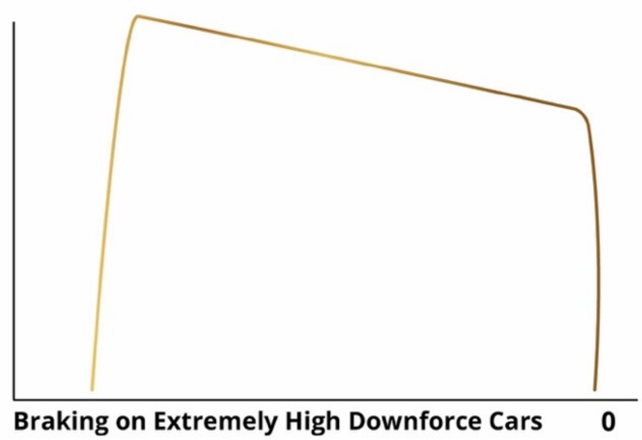
Low Downforce vs High Downforce Under Braking



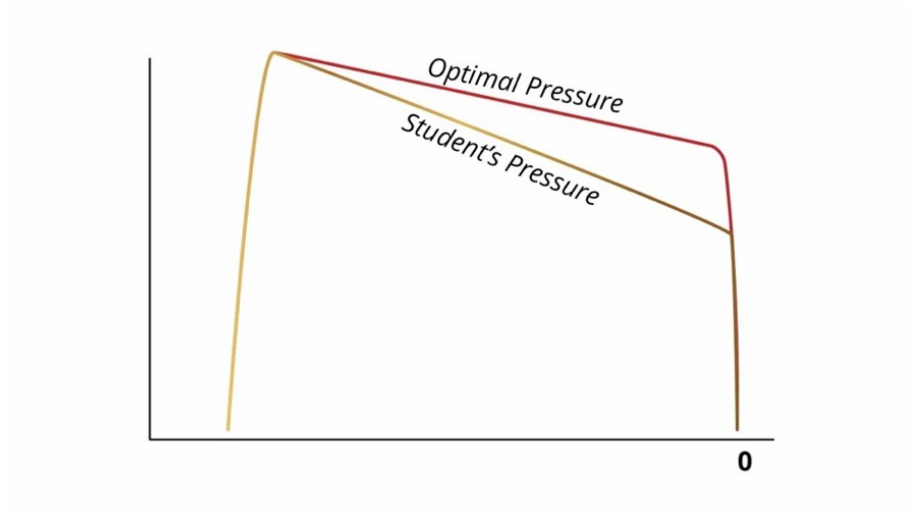
In cars that benefit heavily from downforce, like a winged open wheel car, the amount of braking capability increases with speed. At higher speeds, you can brake harder without locking, but your speed will quickly drop, and you will need to decrease your braking force accordingly to prevent locking later in the braking zone. The higher the downforce, the greater the difference between the peak pressure and the terminal pressure.



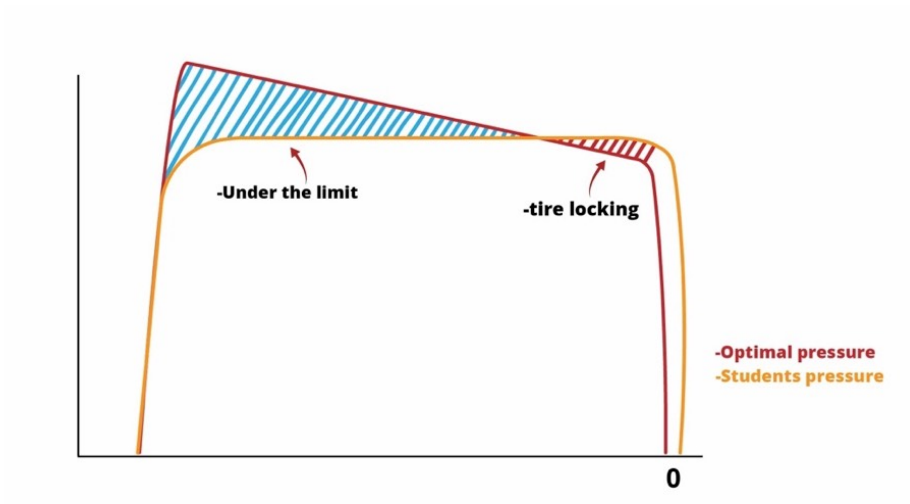
Some cars with extreme downforce can have dramatically different peak to terminal pressures – all the way to double the braking pressure at top speeds in comparison to when coming close to a full stop.



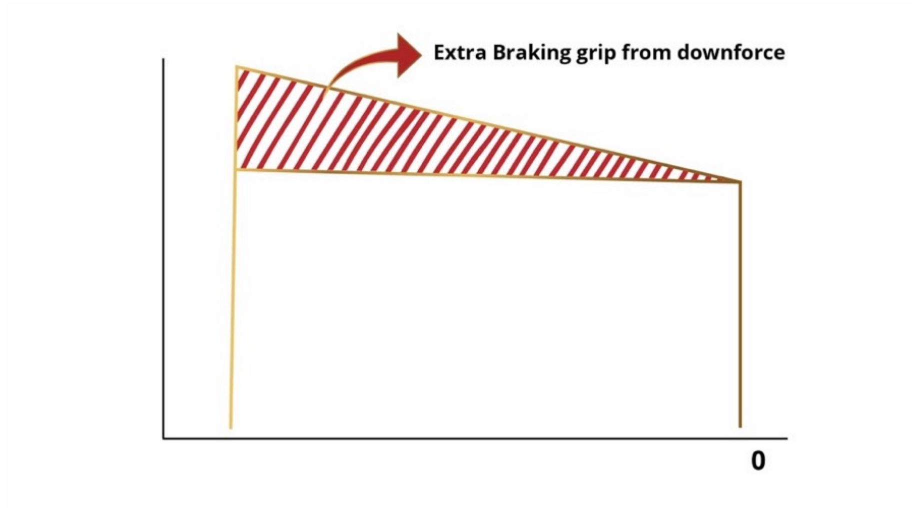
In high downforce cars, it is more difficult to find that perfect braking efficiency on a straight line since it is a moving target. Also, releasing the brakes slowly requires more muscular precision, which takes time to develop (but not that much if worked on correctly). We will discuss the Press Less Technique in the following chapter. Because of this extra challenge, it is very common to release the brakes too much after the initial pressure, bringing the terminal pressure under the limit of grip. Even during a top speed to full stop exercise, the majority of my students release their brakes more than necessary in their first attempts (which is normal for beginners and students!)



Another common mistake includes initially braking under the limit, but then not releasing that pressure enough as speeds decrease, locking up the tires towards the final braking part.



Note that high downforce *adds* grip to braking. Because we're looking at graphs, we may have the impression that we brake less at lower speeds in a high downforce car. The truth is that we brake *more* than low downforce cars at high speeds, and then we come closer to low downforce pressures at low speeds.



4

PRESS LESS TECHNIQUE

One of the trickiest techniques to develop in motorsports is proper brake release. Initially, with less muscular precision and sensitivity, we tend to brake hard and then quickly release the pressure as we turn into the corner. Even when we try to release more slowly, we don't have enough control in our feet.

There are two big reasons we don't have this control right away. First, we haven't yet developed that muscular sensitivity. It's a matter of practice and getting used to feeling it. The second reason is that most drivers actively think about releasing the brakes, trying to "lift" their foot. We have two groups of muscles in our legs and feet. The first group works together to press the foot against the pedal. Let's call them the "down" group. The second group of muscles lift the foot. Let's call those the "up" group.

Now you might think: "Okay, so what I need to do is control the up group so the brakes can be released more slowly!" This is wrong. The solution is to never use the up group in the first place! The brake pedal has its own resistance against being pressed. If you stop pressing it, it will return to its original position on its own. This means we can do 100% of the braking technique using only the down muscles. We press the brake pedal hard, it goes to 100% braking, and then we press *less*. But we're still pressing. It will go down to 90%. Press even less, it will go down to 80%.

The Press Less Technique gives you more precise control of brake release – if practiced correctly and consciously. On the simulator, try the Press Less

Technique by braking to 100%, and then by using the same muscles, release it to 99, 98, 97, 96, etc., and feel those muscles relaxing ever so slightly.

When you get used to releasing the brakes at a ridiculously slow rate, start releasing them a little more quickly. If you can release the brakes smoothly using this technique, increasing the release speed afterwards is easy. The most difficult part is training your muscles to gain the precision of slow release.

This technique allows you to have full control of brake release. You will then have to worry about deciding what *to do* with the braking, instead of wondering *if* you are able to do it.

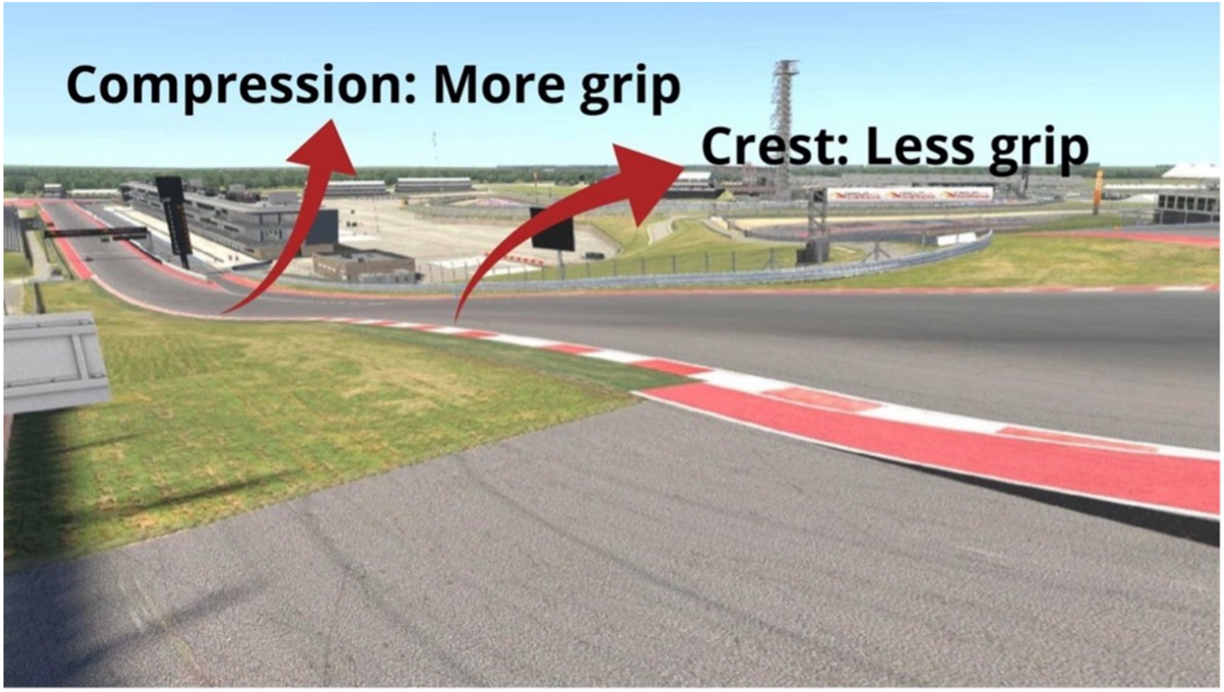
If you make too many adjustments under braking, you'll never really know whether your braking reference is good. It's better to over slow the car by under braking to *clearly* feel that your reference is too early, allowing you to make more efficient adjustments and find the limit faster.

5

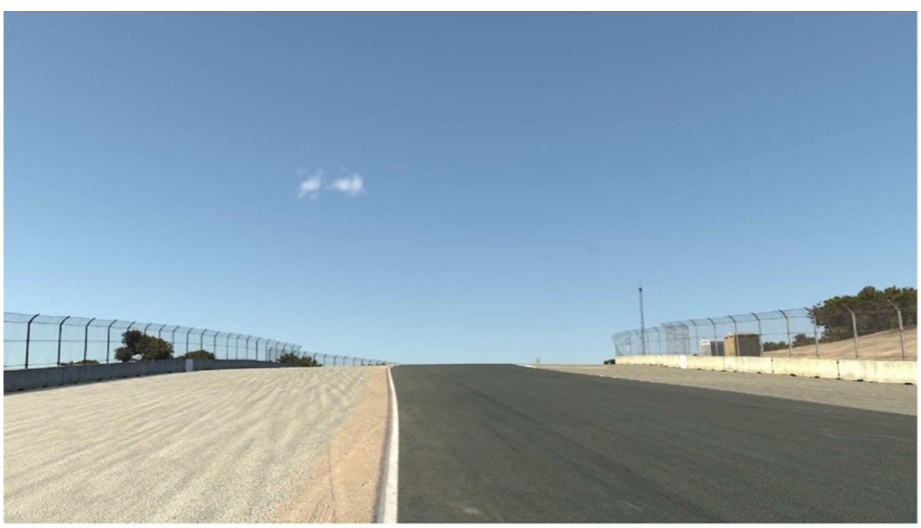
COMPRESSIONS, CRESTS, AND BUMPS

All of the braking examples in the previous chapters are valid for flat surfaces. Changes in elevation will increase or decrease the amount of traction available for braking, and consequently affect the optimal pressures. During a compression, the car gains grip, and the threshold braking pressure is higher.

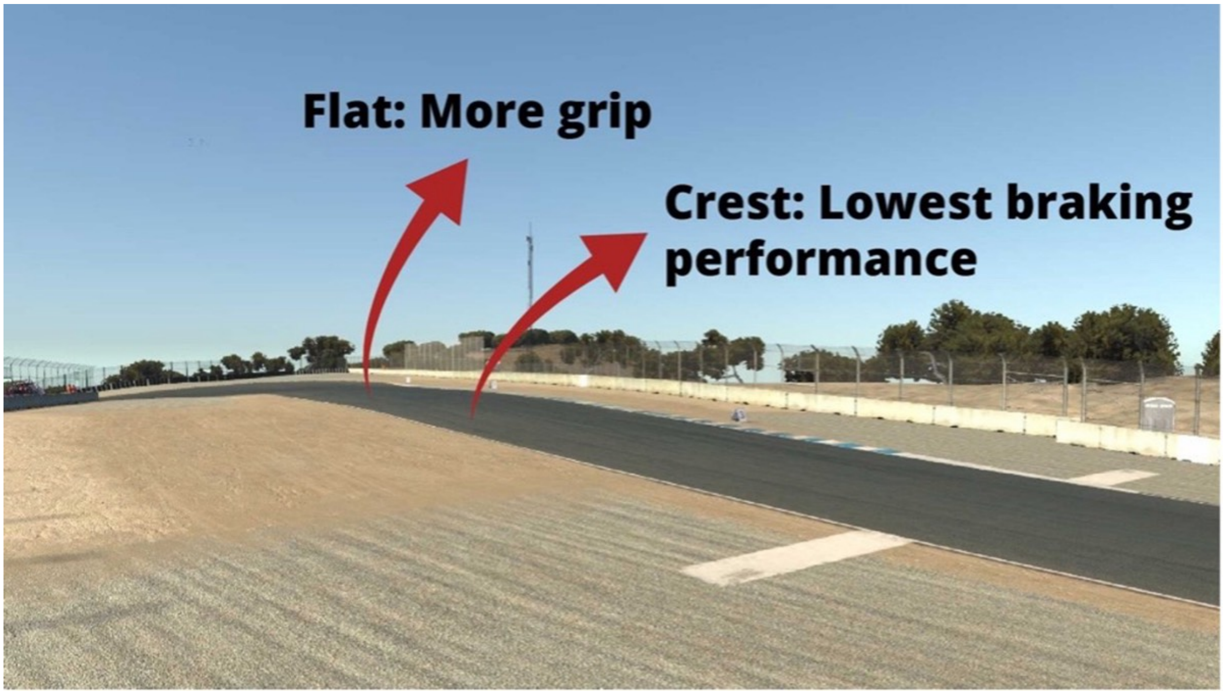
Over a crest, the track starts "falling" away from the car, and the tires have much less contact to it, decreasing the threshold braking limit.



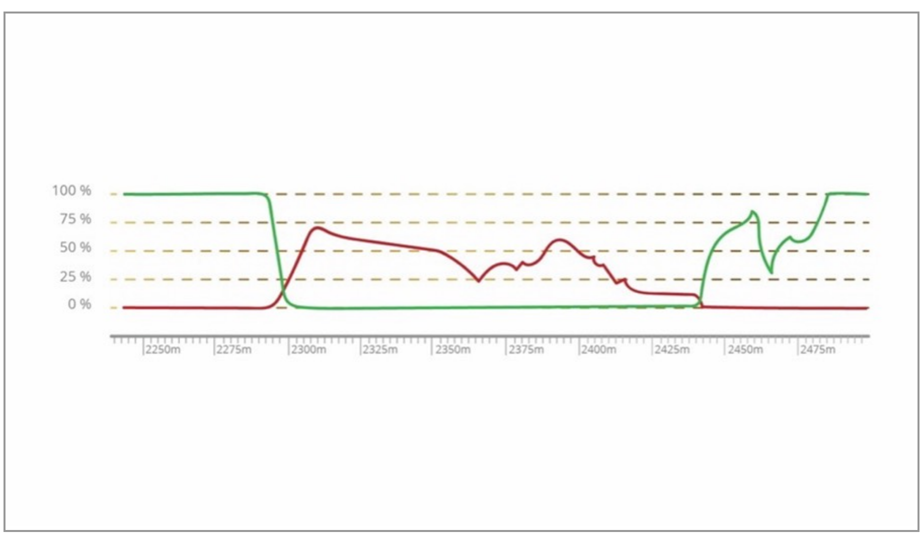
The same braking zone may have both forms of elevation change, making the brake telemetry trace look less common, with ups and downs that you will not find in flat braking zones. Along with Turn 1 at Circuit of the Americas, the braking zone into Corkscrew at Laguna Seca is a great example, as you brake uphill, then immediately run over a crest, and finally go downhill but at a fixed angle.



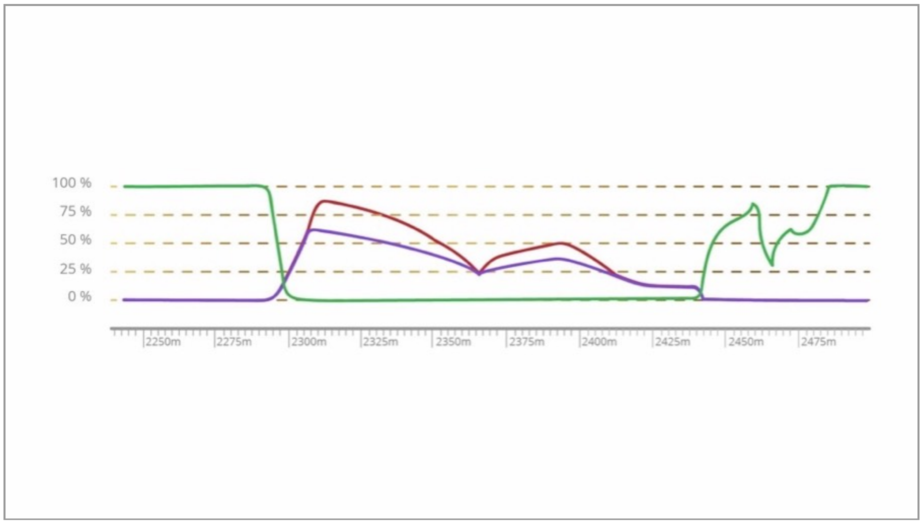
The braking zone to the Corkscrew is a blind right-hander kink. This tricky corner invites you to lock up the right tires, since it forces you to turn slightly to the right at the same time as it offers little mechanical grip.



Right after the small right kink, the crest ends, and now we find ourselves going downhill but on a rather flat surface, which offers more grip than the previous crest. This allows us to increase our braking pressure slightly before turning downhill left-right. The resulting brake trace follows:



The same effect would happen on a high downforce car, but with slightly more pressure in braking at higher speeds due to extra braking grip at those higher speeds.



Braking track of a high downforce car (red) versus low downforce car (purple).

Be aware of changes in track surface or patches, visible through cracks or different colors on the asphalt. These changes are generally bumps that could make you immediately lock up the tires if you are braking too hard right on top of them. Braking should be an active input, and you should be constantly adjusting the input based on track conditions to stay on the right limit: not under, not over.

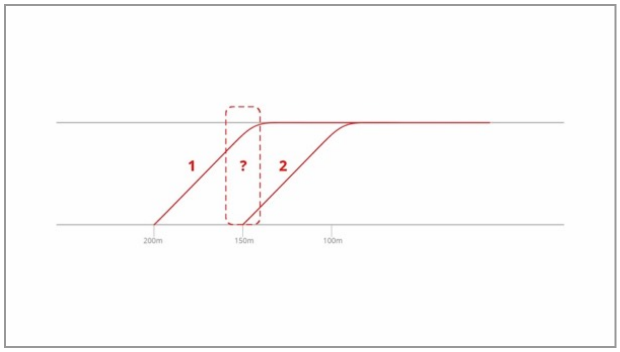
6

INITIAL PRESSURE TO PEAK PRESSURE AND BRAKING REFERENCES

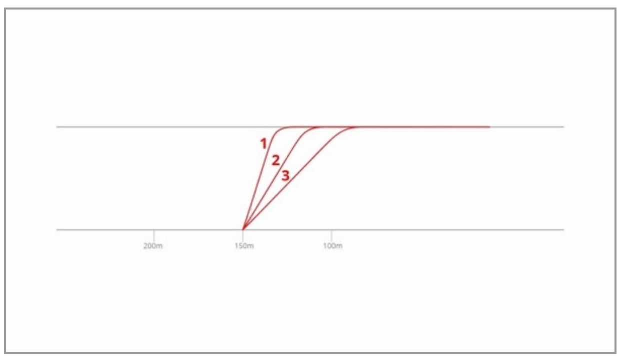
Unlike urban driving, in motorsports we want to reach peak braking pressure as quickly as possible. But we don't want to overdo it. We don't want to "kick" the brakes from a distance with our feet. We want to squeeze the brakes by slightly touching the brake pedal's surface before applying pressure. This gives us much more control over the peak pressure. A good braking technique should allow us to brake at extremely similar pressures lap after lap. If you need to brake at 85% in a corner, you better brake at exactly 85% every lap! This is much more difficult to achieve by kicking the brakes.

At super high speeds, the distance between the very beginning of the brake application and the peak pressure is always much further than you think. By watching replays and reviewing telemetry, you can see how the car moves tens of meters in between initial application and peak pressure. If you are applying the brakes too slowly, this value can go up to 50m or so. There are two problems with this.

Let's say you are braking at the 150m mark. What are you using that reference for? If you are using it for initial brake application and you are braking too slowly, then you might be only reaching peak pressure around the 100m mark. If you are using it for the peak pressure, then your braking might actually start at the 200m mark. When you take too long between initial brake application and peak pressure, your braking references become less reliable and less precise. This makes it difficult to carry the exact same speed into the corner lap after lap, which will hinder your confidence.



The second problem is that if you are not conscious about how slowly you are braking, that distance (initial to peak pressure) will never be the exact same. Sometimes you will do it over 50m, sometimes over 40m, or sometimes over 30m. This makes the car decelerate at a different rate every lap, which kills your consistency.



In practice, try to make sure you are using visual references for the peak pressure or for the initial braking. You can do both at the same track, in different corners. Sometimes a braking reference is great for initial application, but others will be better for peak pressure, depending on where they're placed.

High downforce, light, and stiff cars will accept a faster brake application. You should still squeeze the brakes (touching the pedal before application), but you can apply the brakes quickly, as long as you can still reach consistent peak pressures.

Low downforce, heavy, and soft suspension cars might benefit from a slightly slower brake application. By slower I don't mean 50m between initial application and peak pressure. Blinking takes around 150 milliseconds. Think about it as one blink of an eye for formula cars until you reach peak pressure and two blinks for low downforce and soft cars. Even though it’s double the time, it should still be quite fast and determined in any car.

7

LIGHT HANDS UNDER BRAKING

Peak braking performance is achieved in a straight line. If you are turning into a corner, you can't keep braking at maximum pressure, since that would lock up the tires, activate ABS, and make the car unstable and unresponsive. But are you *really* in a straight line under braking?

The self-centering nature of the steering wheel helps keep the car straight when there is no force acting on the wheel from the driver. If the driver is "death gripping" the steering wheel under braking, the steering might be a few degrees to the right or left, which may considerably decrease the braking performance.

Optimal braking performance happens when the car is laterally balanced: 50% of the weight is on the right side, and 50% is on the left side. In bumpy braking zones, the car might want to adapt to the slight irregularities. Relaxing your hands under heavy braking will allow the steering to adapt to these irregularities almost automatically. If you grip the wheel too hard and try to artificially hold it straight, the car won't adapt to the bumps and might not be balanced laterally anymore. Even being balanced 49% to the left and 51% to the right means you can no longer brake at maximum performance.

From the very beginning of hard braking until the beginning of turn-in, your hands should be relaxed. When starting to turn-in, they should not start acting quickly either. You want to add steering angle slowly and progressively, adding more and more force to the steering towards mid-corner. We’ll talk about the difference between some steering concepts like steering grip, steering force, and steering angle later in this book.

Practice relaxing your hands every time you start braking hard. Create this association in your brain: **brake hard, light hands**. They should happen at the exact same time. If you were already in a straight line, your hands should already be relaxed. If you were coming from a corner into some braking, this technique will help even more. If you keep turning the same amount and start braking, you’ll immediately lock up the tires or lose the balance of the car. Remember that you have a limited amount of traction available for turning and braking, so 100% braking means 0% turning, 50% braking means only 50% turning, and so on.

8

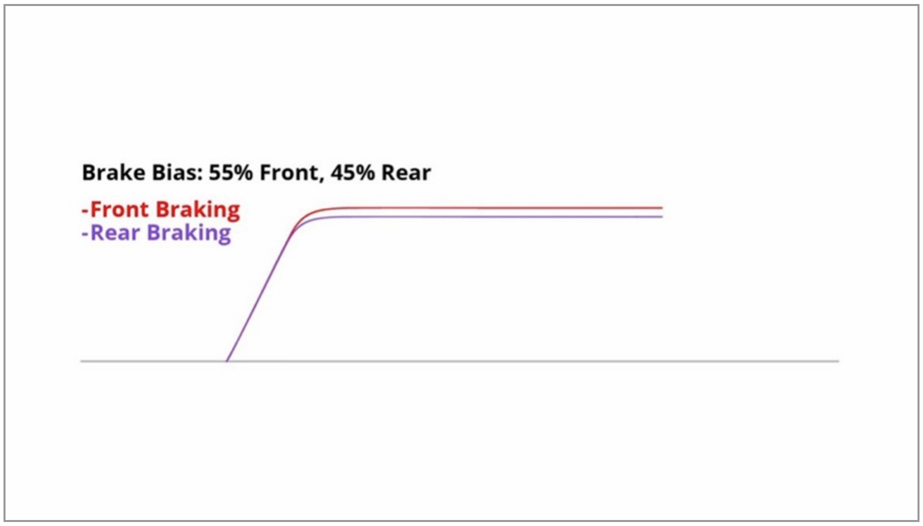
INTERFERENCE BETWEEN ENGINE BRAKING AND BRAKING

When applying brakes in a straight line, the tires receive a percentage of the braking force, divided between the fronts and the rears. This can be altered by the brake bias adjustment, when available in the car.

The brake bias can determine, for example, that 55% of the braking pressure will go to the front tires and 45% to the rears, or 56/44, 60/40, etc.

If the brake bias is 100%, braking very hard over the limit would make the front tires lock completely and the rear tires still roll freely. If the brake bias is 0%, braking very hard over the limit would make the rear tires lock immediately and the car spin right away.

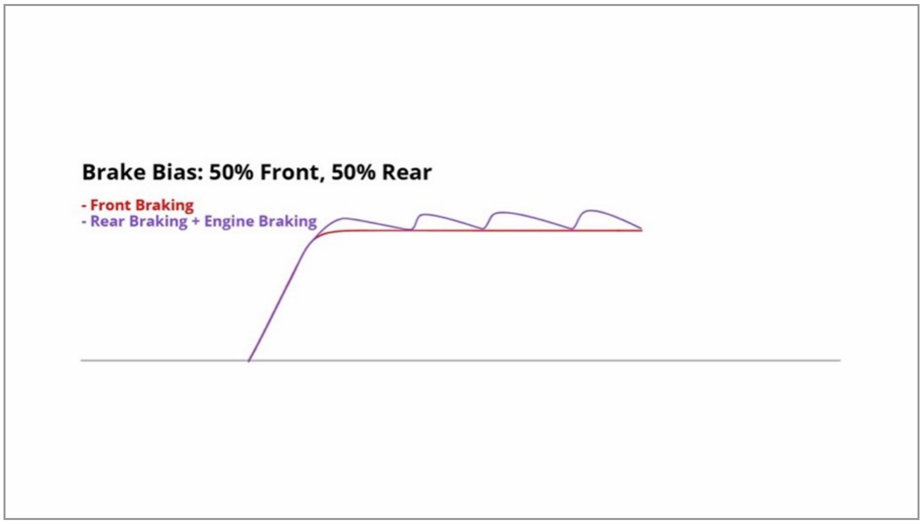
In a hypothetical situation where we're braking from high speeds in neutral gear (no effect from engine braking in the rear tires), brake bias remains constant throughout the entire braking zone.



However, engine braking will always factor in, as we won't clutch in when braking or put the gear into neutral every time we brake into a corner. We then need to understand the behavior of engine braking to understand the braking performance of a car. This will affect the braking both under braking and while turning. Learn to control the engine braking of the car by timing the downshifts to gain extra balance control at all stages of the corner.

Engine braking works like light braking on the driven tires only. If the car is front-wheel drive, then engine braking will affect the front tires. If the car is rear-wheel drive, engine braking will affect the rear tires. All-wheel drive cars will have a neutral effect since the engine braking will be applied to all four wheels. The majority of racecars are rear-wheel drive, so in this chapter we'll talk about this type of engine braking. When you release the throttle, the engine starts sucking energy from the tires instead of giving energy to them. The higher the RPM (revolutions per minute), the higher the engine braking effect. This "light rear braking" will add to the actual braking of the car, affecting its final brake bias.

If the car has 50/50 brake bias, the extra engine braking might make the final braking bias (braking + engine braking) somewhere around 47% at the fronts and 53% at the rears, for example. If you downshift less aggressively, meaning you downshift later into the braking zone, allowing the RPM to decrease a little bit more, there will be less engine braking, and the final braking bias might be somewhere around 48% at the fronts and 52% at the rears. In the end, what you have is a **dynamic final braking bias** that you can adjust from corner to corner by adjusting the timing of your downshifts.



Some cars will benefit from downshifting very aggressively (be careful not to blow up your engine if you downshift too fast and bring your RPM too high!), as you can make the car rotate slightly more if the car tends to understeer, for example. But if the car already oversteers, it might be better to be more patient and downshift later to prevent excessive engine braking and even more oversteer.

In front-wheel drive cars, the engine braking happens on the front tires, adding extra stress to them. That means the effects of engine braking are inverted in FWD cars, so downshifting more quickly will make the car less prone to oversteer, while downshifting more slowly will make the car rotate more.

The biggest mistake regarding downshifts is not being aware of their timing and rhythm. A slight difference in how quickly you downshift in the same corner on different laps might make the car behave differently, which will cause inconsistency and unpredictability. Consciously analyzing the speed and rhythm of downshifting will allow you to fine-tune the balance of the car at every single corner.

MODULE II

INTO THE CORNER

1

IMPORTANCE OF INITIAL CONDITIONS IN A CORNER

The key to mastering motorsports is in being able to manage entry and braking. Whenever there is a small change to the entry positioning of the car, the rest of the corner will be affected. Even when there is no braking involved at all, the turn-in point of fast corners still pretty much determines the outcome of the corner.

Entry is cause, exit is consequence.

Let's say we're about to do a tight 90-degree corner on a street circuit surrounded by concrete walls. The amount of control a driver has on entry right before braking is 100% (if there is a straight before that corner). The driver can choose where to position the car right before decelerating, and how late to brake. They can safely position the car as close to the walls as possible without too much risk.

As soon as the driver starts braking, the amount of control decreases drastically. Now the car is on the limit, and positioning the car laterally is not possible anymore (unless you decide to not be on the limit under braking), except to turn into the corner and commit to a line. The driver might be able to increase rotation and decrease the radius of the line or decrease rotation and open up the line if they turn in too early or are oversteering, but that's it. As soon as you commit to a line and braking reference, the amount of control is limited. At this point, being as close as possible to the apex wall is a little trickier, as you have a lot less room for error and a much smaller range of possible lines. This stage depends entirely on the initial braking point and line.

As soon as the driver starts accelerating out of the corner, the number of corrections possible while committing to throttle are also very limited. I call corner exits a “consequence” since you are pretty much along for the ride through the exit based on how you dealt with the corner in the earlier phases. If you get back on power too late and the car is slow, you might rotate the car more than necessary and you will not use the whole track on exit. If you get back on power too soon or with the car pointing too much to the outside, you won’t be able to stay on track without lifting the throttle, which will also slow you down. This means that for a good exit, you have to thread the needle on entry and mid-corner to position the car perfectly, and then harvest that line. This stage is the one where we have the least amount of control, and it is where most drivers will hit the wall on exit.

This brings us back to the initial conditions of a corner. The initial conditions is the most important phase in pretty much all corners. Changing the car’s positioning or angle (discussed in more detail in a subsequent chapter) even a little will affect the entirety of the corner. If the driver is unaware of these small differences, the car might behave differently every lap, causing inconsistency and unpredictability. If the line on entry is not on the limit, for example, the driver will rotate the car less before the apex, meaning the exit line will see the car pointed a few degrees to the wall on the exit, which drastically impairs the exit speed since the driver will have to make a small correction on the throttle to not hit the wall. If the driver turns in a little too late, they’ll instinctively look for more rotation so as not to miss the apex, which could cause oversteer. That instinct is so subtle that the driver won’t understand why the car lost the rear on this lap but might not have on the previous one. Having a different line on entry each lap but expecting the car to be in the exact same place at the apex is a big source of frustration among drivers, since the balance of the car will vary depending on the initial conditions of the corner.

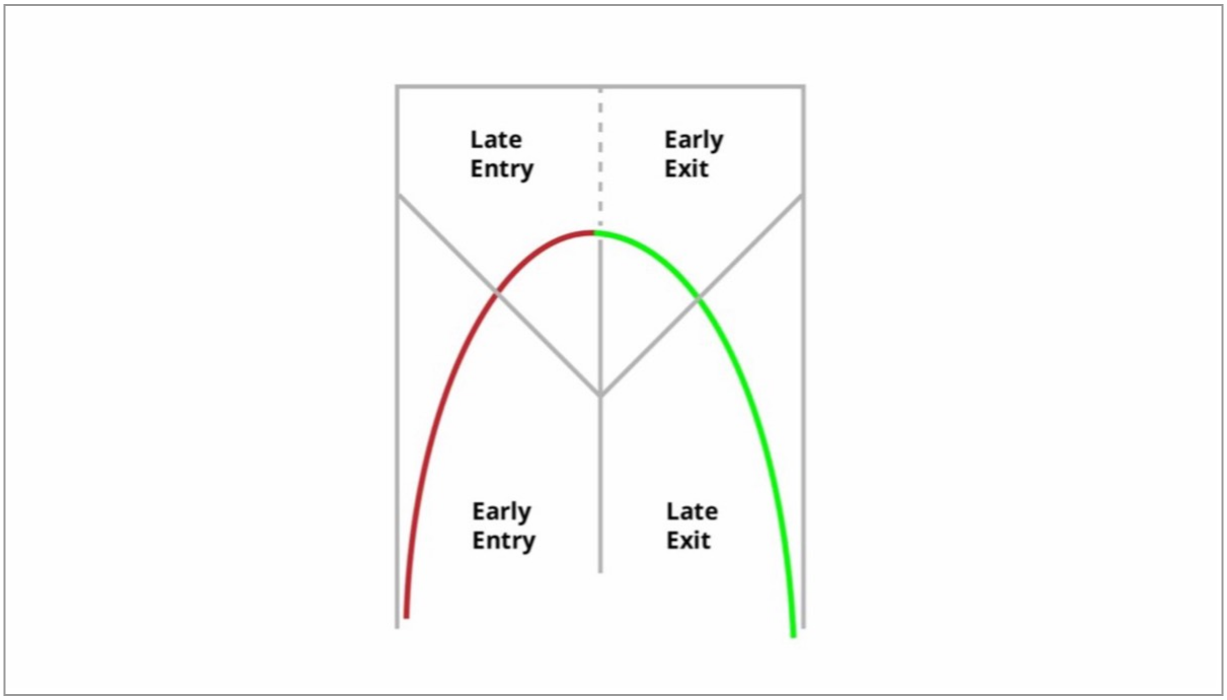
2

THE STAGES OF A CORNER

If you have researched or studied the stages of a corner on the internet, you might have found a few explanations that describe numerous or complicated steps for a single corner. I've found some advice that divides a corner into as many as six or seven steps. I believe that these approaches are next to impossible to apply while driving. There's no way you'll be able to think about seven different things in just a few seconds.

With an understanding that the human brain can only consider so much before becoming confused, I have come up with a much simpler division that encompasses the most important car handling concepts we'll work on in this book.

The cornering stages can be divided into four, distinguishing that the hard braking zones are a separate step. Hard braking zones in a straight line happen *before* early entry. That means the first stage described in the image below already involves some degree of turning. Remember that this division is applicable for corners where braking is involved. Cornering while only lifting or keeping the throttle flat should have a different approach and will be discussed later.



Let’s discuss each stage.

Early Entry

Early entry is where the initial transition from peak braking should start. This is where the first degrees of steering angle show up and the weight transfer starts shifting backwards (due to brake release) and outwards (due to steering).

One of the most common mistakes at this stage is initially turning the steering wheel too much or too quickly. We want to slowly transition the brake release to the steering input. If we do it too quickly, the buildup of rotation towards the apex will be unstable and peak lateral grip won’t be reached. In simpler words, trying to reach too much rotation that early in the corner will cause the car to either understeer or oversteer, and you’ll spend the rest of the corner trying to fix the problem instead of going fast.

The totality of the corner should encompass *one big motion* – one big buildup of rotation that will peak at the apex before we launch the car out of the corner.

It should be noted that one of the key characteristics of this phase is the tendency for the car to oversteer due to heavy weight on the front tires from the initial trail braking phase, as well as higher RPM and heavy engine braking effects (if the car is rear-wheel drive).

Late Entry

The second quarter of the corner is the final build up to **peak rotation**[1] before we launch the car out to the exit. Here, we should be committed to getting as much rotation as possible and testing the grip limits when learning a new car/track combo. The speeds, RPM, and the braking pressures are lower, so the car tends to oversteer a lot less than in the previous phase. Each degree of rotation that happens here is one less that will need to happen on exit. The safety of a corner’s exit is directly correlated to the amount of rotation we achieve at this stage. The more we rotate on late entry, the better and safer our two final phases will be. This stage is all about getting as much lateral grip for rotation as possible.

The most dangerous and common mistake in this phase is to hesitate when it comes to turning and rotating the car. Failing to rotate the car in this phase is the main cause of exit spins and crashes, both in the simulator and in real life.

The late entry is the final build up to what I call the **Maximum Rotation Point (MRP)**, a key concept we will discuss in depth throughout this unit.

Reaching peak rotation in the late entry phase depends largely on the previous phases, like braking and early entry. If your line is correct, you should be able to commit to rotating the car as much as possible without hitting the inside limits of the track too early.

Early Exit

Early exit starts at peak rotation (or the Maximum Rotation Point). This is when we start accelerating. Ideally, at least 50% of the rotation should already be done and the rotation should start decreasing as the car gains speed out of the corner. This is a very important thing to remember. No rotation should be gained at this point. Rotation and speed are always inversely proportional, and trying to gain rotation after accelerating will cause the car to go over the limit and oversteer or understeer. If this doesn't happen when you gain both speed and rotation at the same time, that means you were under the limit between late entry and early exit.

The most common mistake at the early exit phase is to unwind the steering wheel too much, likely due to fear of losing the rear on power or hesitating when it comes to getting as much rotation as possible. This causes you to rotate below the limit at a lower speed. Then, when you realize you need some extra rotation at the late exit phase, the car is now too fast to handle it. Hesitation on early exit is also one of the most common causes of spins and crashes on the late exit phase.

Late Exit

Late exit is the stage where we have the least amount of control of the racecar. Everything that we've done in the earlier phases (braking, early entry, late entry, early exit) will determine where we'll find ourselves in this phase.

Exits are consequences. They rely on what happened on entry. The speeds are higher, the rotation should be decreasing, and we should reach peak acceleration, allowing the car to drift wide to the edge of the track on the limit.

These stages will be referred to throughout the book when describing various concepts.

---

1 By rotation, I mean yaw rate, or degrees of turning per second.

3

ENTRY SPEED

The speed on turn-in is one of the most important factors for consistency and predictability in racing. Carrying different speeds into the corner is one of the biggest sources of inconsistency in racing, and the biggest enemy of your confidence. If you can't carry the exact same speed into a corner, the car will behave differently each lap, making you scared of driving on the limit.

Having a precise braking reference is the most common tool for consistent speeds on entry. But that alone is not enough. If you brake in the same exact place, but with varied pressure, you'll still carry inconsistent speeds lap after lap.

The second most common tool is to choose a specific gear to decelerate the car to more specific speeds for each corner. This helps a lot, especially if you are still learning the track.

When you want even more consistency, my advice is to not only choose a gear, but to also note how high the RPM are in that gear. For example, third gear might be great for two corners, but if one is slightly faster than the other, you can listen carefully to the engine and try to carry higher RPM into the faster one. This works because you can use the engine sound as a reference for how much speed you are carrying with more precision.

Remember that this will always operate in conjunction with your other inputs. Braking references and braking pressure must still be very precise and consistent so you can reach your gear and RPM goals. These tools combined will allow you to expect similar behaviors lap after lap. When downshifting in a similar way every time, you'll also have similar engine braking behavior, which affects the rotation of the car a lot more than we expect. We'll discuss the Three Tools for Rotation later in this book.

4

POSITIONING AND ANGLE

Considering the positioning and angle of the car might seem simple and obvious, but the problem with racing is we try to do too many simple and obvious things at the same time. We will feel that we already know something – that it seems so easy, but I want you to stop and ask yourself one thing: are you really extracting absolutely *every* factor to the extreme?

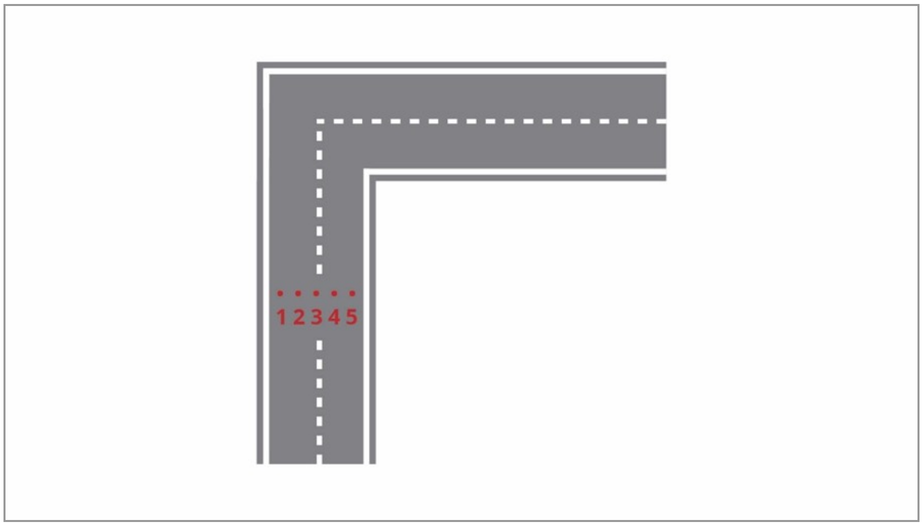
Positioning and angle are concepts I developed when coaching beginners, but after a while I noticed it made sense to explain these concept to advanced drivers as well so they could bring these "simple and obvious" things into their consciousness.

After some experimenting in coaching, I found it incredibly useful to analyze lines in the initial conditions of a corner, sometimes helping drivers find up to a tenth of a second in just one corner. As with every technique we learn, we'll approach these ideas in an exaggerated way and then reduce them to their specifics.

Positioning

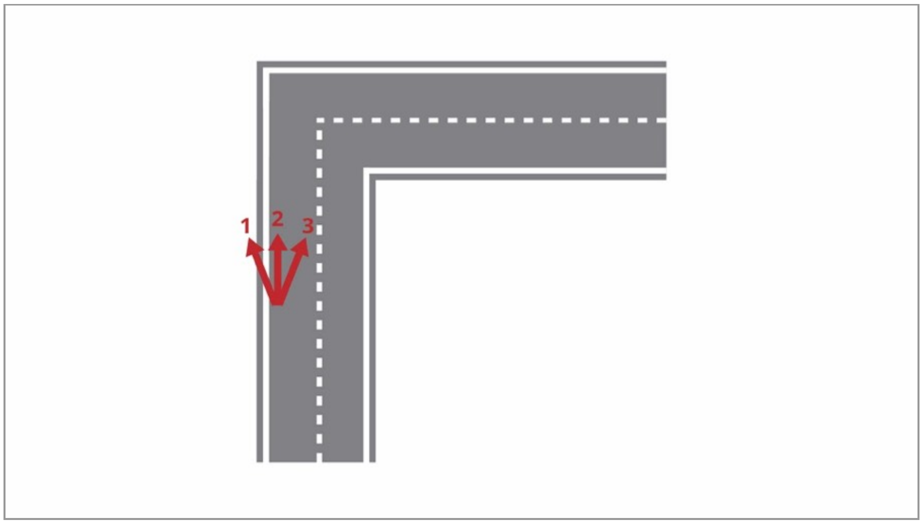
Positioning is where the car is placed laterally on the track. You can be on the left of the track, in the middle, or on the right (and everywhere in between). In this case, the outside of the track is preferred for entry positioning, but there are exceptions. If you can do a corner with ease, for example, you don’t need to go all the way to the outside on entry, since that would make you drive a longer distance and lose time.

Think about positioning at the beginning of any arc. It’s useful to think about your position not only right before braking, but also at any change of direction in compound corners since they’ll determine the proceeding arc.



Angle

Angle is where the car is pointed. You can be pointing outwards (1), inwards (3), or parallel to the track (2). If you are already positioned on the outside white line, for example, you must be parallel to the track as soon as you start braking to maximize track usage (if it’s a hard braking zone).

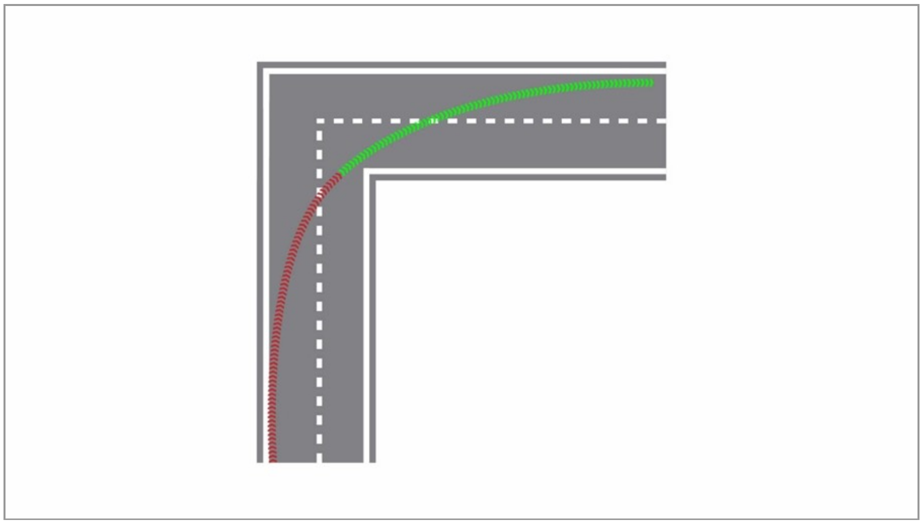


The angle is mostly going to be important in corners that are close to others. Belle Isle at Detroit offers a good example.

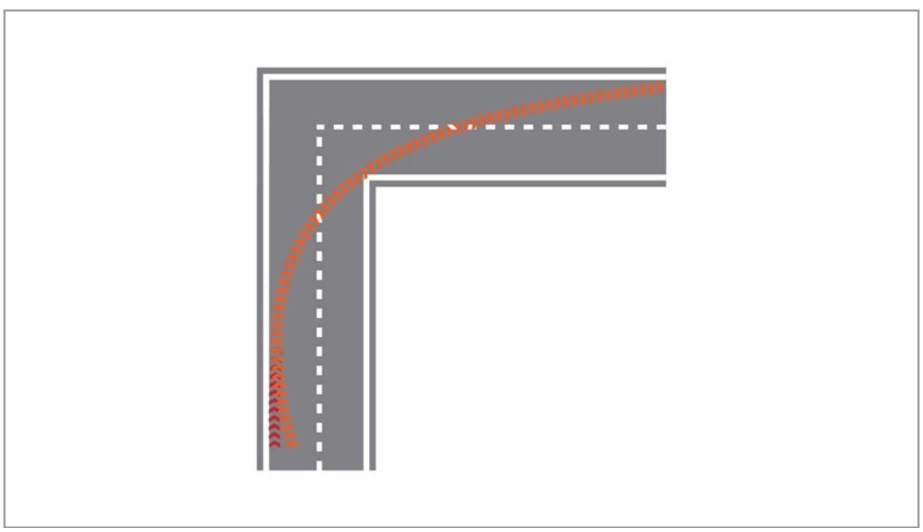
Detroit, Belle Isle, Turns 5 and 6

The most common mistake in this corner is to “relax” in between the left hander and the right hander (blue line). This affects your entry positioning and angle for the second corner, hurting the lap times. When corners are close to one another, make sure you are optimizing them as quickly as possible to not leave lap time on the table!

In any 90-degree corner (image below), for example, if the car is completely parallel to the entry, the car will only need to turn 90 degrees.

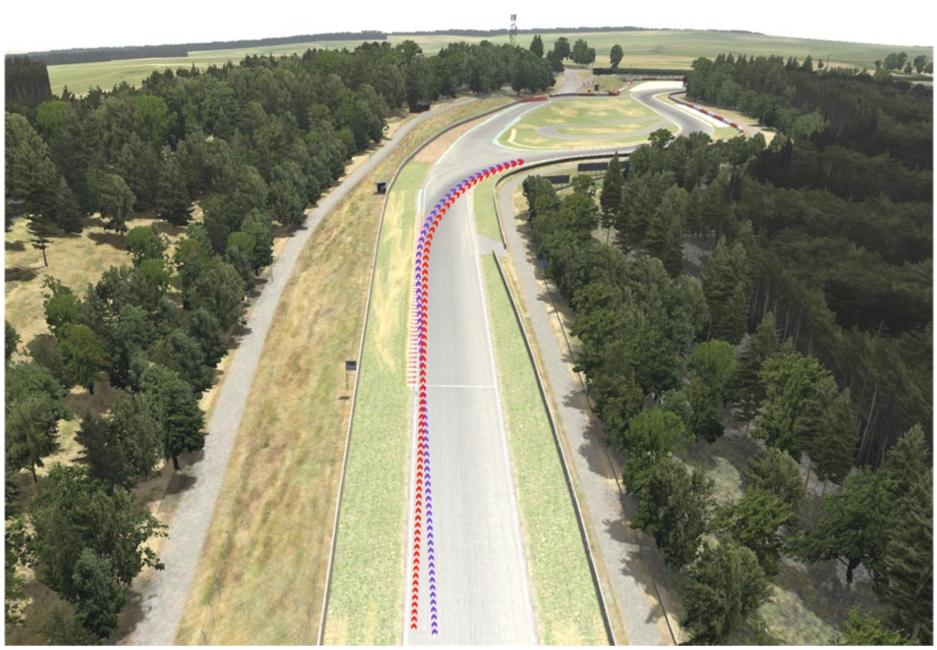


If the car is pointing to the outside, even by three degrees, the entire corner is now 90 + 3 = 93 degrees (orange line below). This means the positioning and angle the driver chooses at the beginning of a corner might make the corner more difficult and longer than it needs to be.



Bringing these concepts to the surface allows you to test more deliberately and make more subtle adjustments that will bring consistency to your driving. Of course, this is just a baseline concept, and there are some exceptions. In some corners, it might be better to start braking with the car pointing slightly outwards.

Think about Les Combes, at Spa. Depending on the simulator, car, track surface, conditions, etc., it might be better to use the curb on the left to open up (improve your positioning by making it even wider) for the corner. However, that curb starts pretty late in the braking zone, so we can't use it if we're starting to brake parallel to the white line. This is, of course, in case it is worth adding an extra few degrees to the corner for the sake of gaining more track usage (better positioning, but worse angle), and in case the curb provides good grip. You can know if these adjustments are worth it mostly by trial and error, especially when the differences are subtle.



Spa-Francorchamps, Les Combes corners.

In this case, we start braking with the car a bit further from the white line, but pointing diagonally outwards to eventually use the whole curb when it starts. In this example, we benefit from better positioning (car is using more of the track on entry) but we sacrifice the angle a little bit (car is pointing a few degrees to the outside at the beginning of braking). For some cars, that sacrifice will be worth it; for other cars, it won't.

You can measure and think about position and angle anywhere, but the three most important points are the breaking point, the turn-in point, and any changes of direction.

Braking Points

If you are braking on the limit for a big deceleration, the best line is a straight one. If you turn even a little while braking, you'll shift the balance laterally away from the ideal 50/50, and you'll lose braking performance. Having light hands under braking can help make sure that your car is perfectly straight and adapts to small imperfections on the road. Braking on the limit will lock you in a straight line, making you unable to change your direction too much. Turning just a few degrees under heavy braking decreases the ideal pressure by a considerable amount and will cause locking or ABS. It's best to think about the positioning and angle at the very moment you start braking. In places where it's impossible to brake in a straight line, measure how much you need to steer to be able to turn and not hurt the braking performance too much.

Turn-in Point

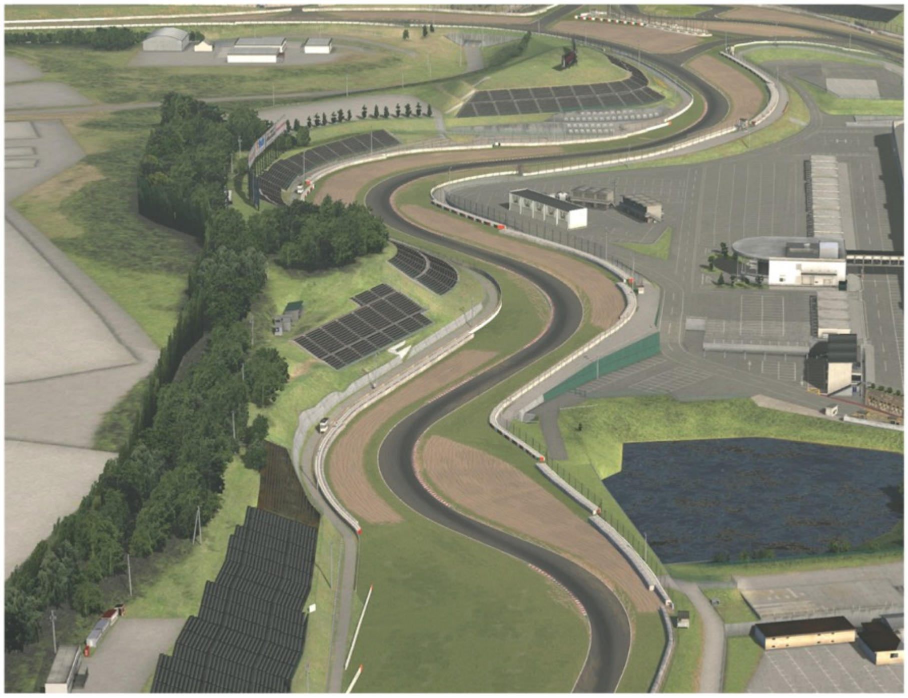
If you are braking hard in a straight line, your positioning and angle at the braking point will also determine where your car will be by the time you start turning in. When there is turning involved *before* the turn-in, either because there is no braking before the corner or because there is some braking with turning combined, pay attention and measure precisely where you are placing your car at the turn-in point. A slight change in turn-in positioning and angle will carry through the entirety of the corner! This means that if you have three compound corners one after the other, one small change in the initial positioning and angle will also affect the next two corners. Most of the time this will cause a snowball effect, where the difference in car placement will be even bigger for the second and third corners. Remember, the initial setup of a corner is the most important stage and will drastically affect the rest of the corner.

Changes of Direction

When driving through chicanes or compound corners with changes of direction, the moment you make the change will give you two things to consider, both of which have aspects that will be discussed further in subsequent chapters.

First, your turns will depend heavily on your turn-in positioning and angle. If you want to consistently change direction at the same place with the same angle, you'll have to turn the car in at the exact same reference you set for the entry every lap. Also, remember that the speed you carry into the corner will affect the radius of the arc you'll be able to build.

Second, the positioning and angle of the change of direction will affect the next corner and the car needs to be placed consciously so you always get the same exit.

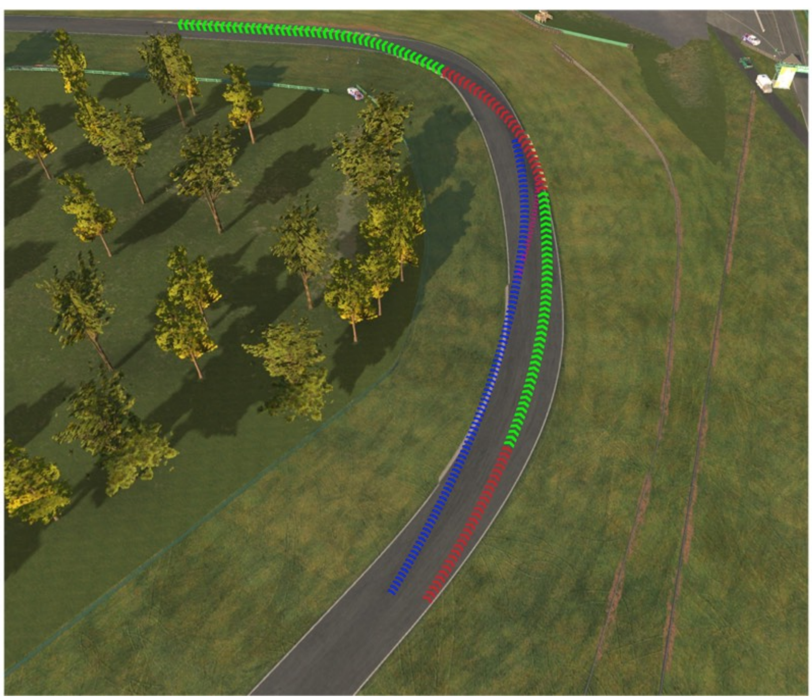


Suzuka Esses

5

CHECKPOINTS

As we progress in our racing technique development, positioning and angle can become natural very quickly, especially in single corners coming from a straight. But compound corners or corners that are very close to one another can steal your attention and trick you into driving the wrong line when your timing matters most.



Virginia International Raceway, Turns 2 and 3

Blue is the line that many drivers take by trying to apex the first corner, and then realizing they are too close to the inside, try to correct the line (purple) before the next left hander.

Checkpoints are places where the positioning and angle will determine the outcome of the next corner. Think of connecting points between corners that you need to hit if you want to maximize your racing line (we'll talk about deceiving corners later). In the example above, the beginning of the braking towards Turn 3 is the most important moment of this sector, so that's our checkpoint here.

I use the checkpoints concept only when drivers are missing important techniques due to tricky corner sequences. They're a way for you to re-analyze your approach and remind yourself what you should be aiming for in your racing line.

Checkpoints are most common in two places: corner entry and changes of direction. This is because as soon as you find yourself in the right positioning and angle at the beginning of a corner, or when connecting compound corners, the remainder of the corner becomes much easier to get right (it's impossible to get any corner perfect if the initial conditions are wrong).

Hitting checkpoints right in every lap will make you much more consistent over a stint and will allow you to feel more subtle changes mid-corner. It's impossible to know how a small change in speed might affect the rotation of the car mid-corner if the car had a different positioning and/or angle on corner entry.

Make sure you are consistently positioning and angling your car and be aware of your lines when the grip matters the most, avoiding traps in deceiving corners that make you drive the wrong lines and lose consistency.

6

SENSING THE POSITIONING AND ANGLE WITH PRECISION

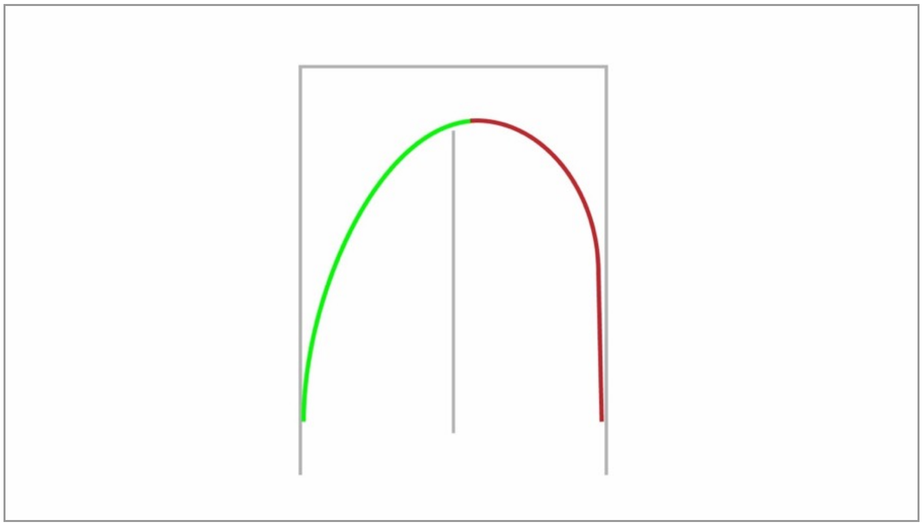
To improve your consistency when hitting marks and to always position and angle your car in the same way, try to align something on track to some reference in the car. For example, you can align the white line on the track with something inside the car (like the pillar, the left side of the hood, etc.) to make sure you are using the entire track. Most of the time the driver is not using the whole track because they think they already are, but they never created a visual reference to know when the tires are actually hitting the grass. It might look like your tires are on the verge of hitting the grass, but when you look at the replay there is a whole tire width still available. Check your replays!

You can also use curb in changes of direction to make sure you are positioning your car in the exact same place. You can analyze both the positioning of the car ("How far am I from that curb?" or "How late am I hitting that curb on the inside of a chicane?") and the angle ("Am I parallel to that curb by the time I'm hitting it, or am I hitting it on an angle?"). These small details are the answer to questions like why the car always behaves differently on the exit of ess turns.

Every millimeter makes a difference. The most important step for consistency is creating visual references that will help you place the car in the exact same place every single time in a stint.

Positioning and Angle: Examples

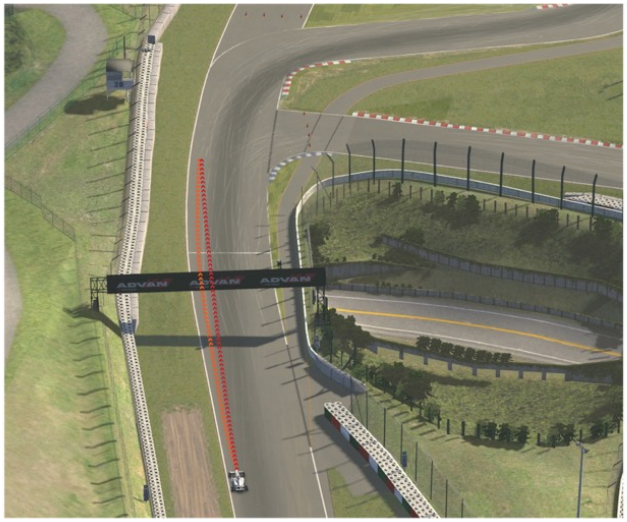
Most corners will have an easy and obvious approach. A hairpin preceded by a straight line with parallel track limits invites us to drive parallel to the white line under braking. That's our positioning and angle.



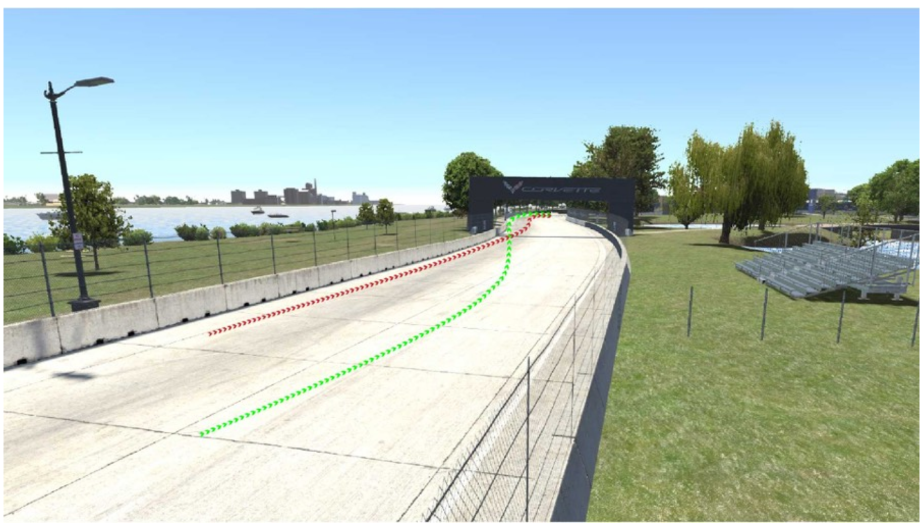
There are, however, situations where it's not as simple as having the turn-in point be parallel to the track limits that precede the corner. There are situations where the track limits are not a straight line. These places require a lot more experimenting and thinking before we find the optimal line.

Let's see some examples of corners that don't have an obvious entry positioning and angle:

The final chicane at Suzuka can be a trap when it comes to braking performance and car balance. Braking at maximum capacity requires a perfectly straight line, but the curvy braking zone of this corner prompts the driver to follow the white line and then turn slightly to the right (orange line). This unloads the right side of the car, causing tire locking (either front, rear, or both, depending on car setup). In this case, a possible solution is to start braking while pointed away from the white line so you can brake on a totally straight line before meeting the white line again (red line). In this case, the checkpoint in mind is the one at the very turn-in phase of the corner, where you should be as close as possible to the white line.



Suzuka Chicane



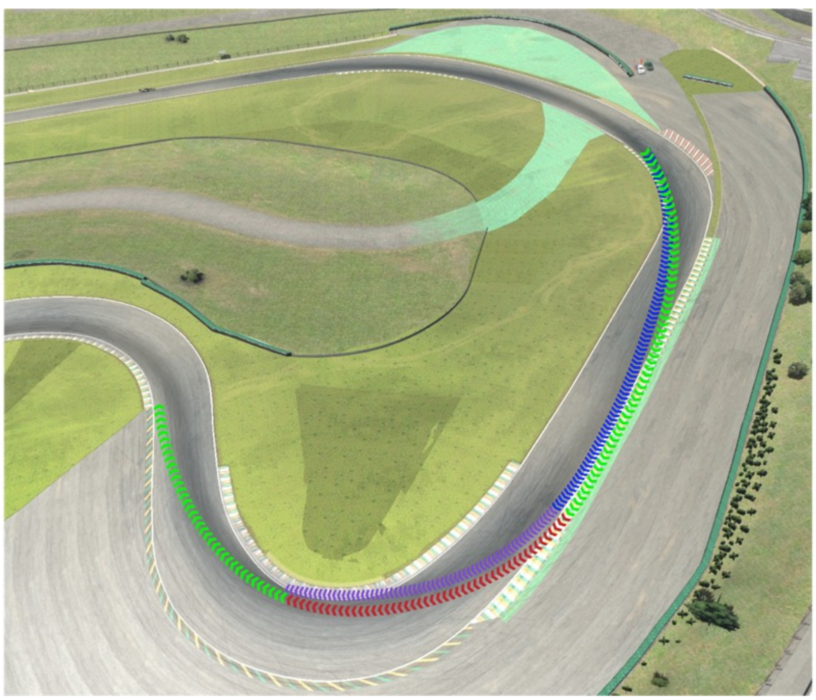
Detroit (Belle Isle), Turn 7

Turn 7 at Detroit is a deceiving corner. It invites you to stay on the left (red), sending you into a small left kink before the actual braking zone. This catches many unaware drivers, hurting their cornering performance drastically for the actual right-hander.

7

DOUBLE LEFTS AND DOUBLE RIGHTS

As I have mentioned before, when you have two consecutive corners with little space in between them, the entry to the second corner will be affected by the exit of the first one. Let's see some examples:

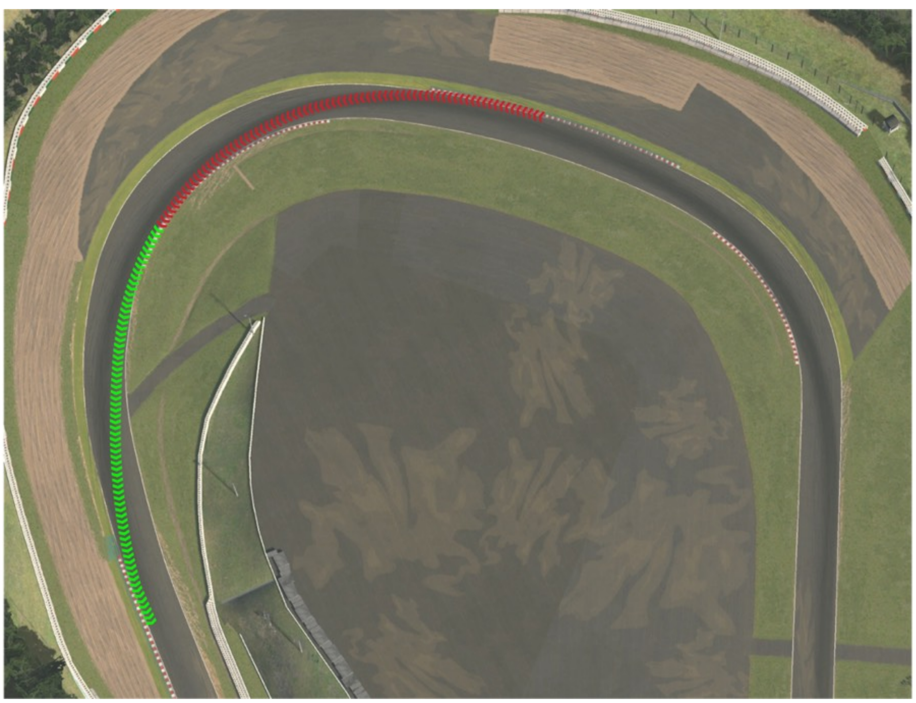


Interlagos: Ferradura, Laranjinha and Pinheirinho corners

The connection between Ferradura, Laranjinha and Pinheirinho at Interlagos is a perfect example of a double-right corner. Positioning the car imperfectly on the exit of the first turn causes a problem for the next two turns. Not using the entire track on exit (blue line) also hurts your positioning and angle for the next corner (purple line). This is a very common mistake in this sector.

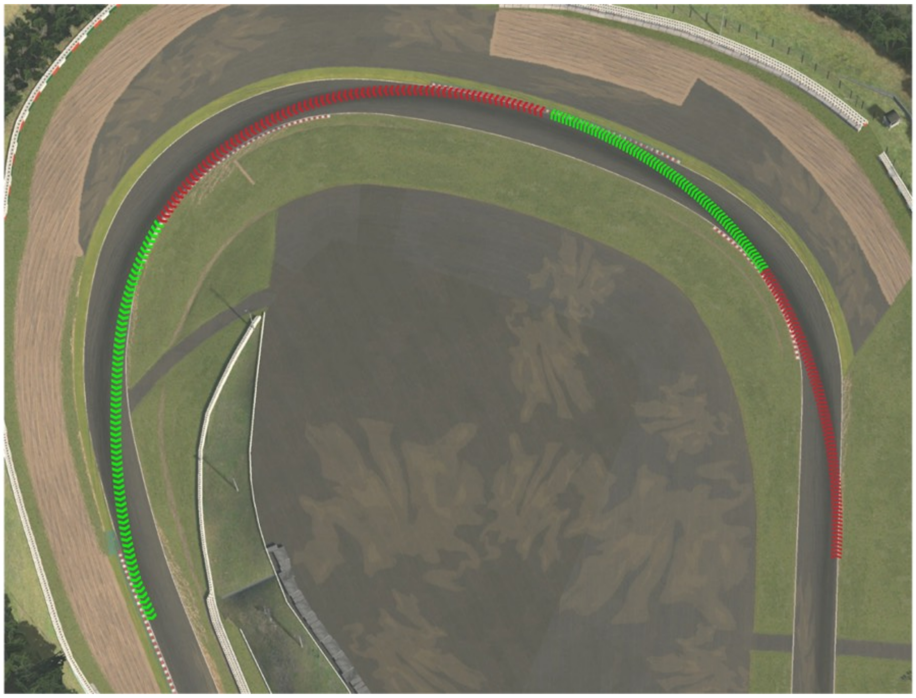
The biggest challenge in this situation is being able to drive the car all the way to the exit of the first turn by having the right timing for acceleration. Addressing this with the Maximum Rotation Point and its adjustments in compound corners will be discussed soon.

Spoon at Suzuka is another famously tricky double corner that punishes you for not using the whole track in between corners. For this example, let's reverse engineer the optimal line, building the exit corner before the entry corner. Reverse engineering a corner will ensure that we get as much exit speed as possible by planning the lines that start the sector. It should look like this:

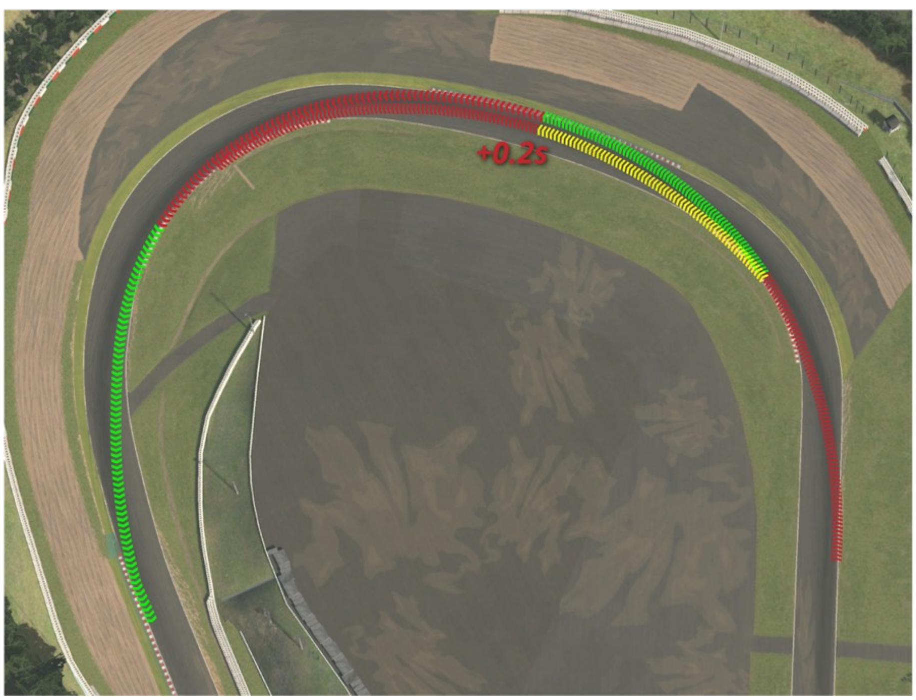


Suzuka: Spoon

Now that we know the ideal entry point for the second corner, let's connect the exit of the first one to it:



Seems easy, right? But what happens most often is this (yellow to red):

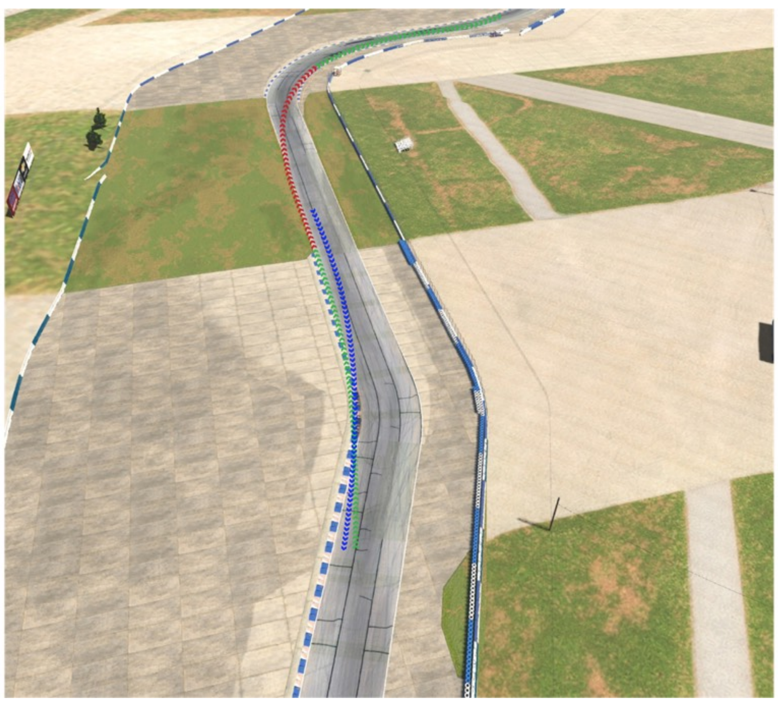


The fact that the two corners are so close to one another can cause confusion, and many drivers will lose their laser focus of positioning and angle in between them. Remember: missing the positioning and angle between close corners will double the lap time performance hit.

8

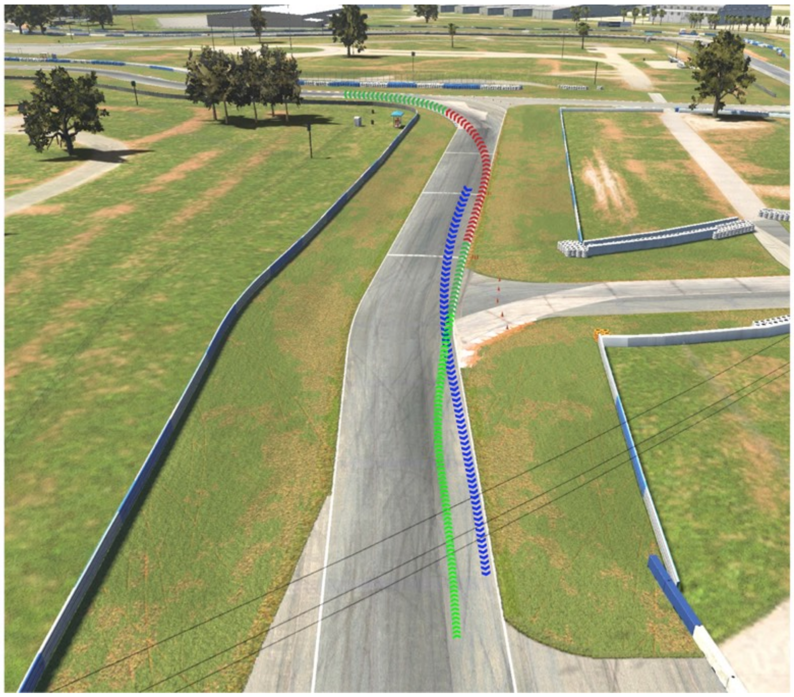
DECEIVING CORNERS

A deceiving corner is one that throws you away from the fastest racing line. Let's analyze some deceiving sections:

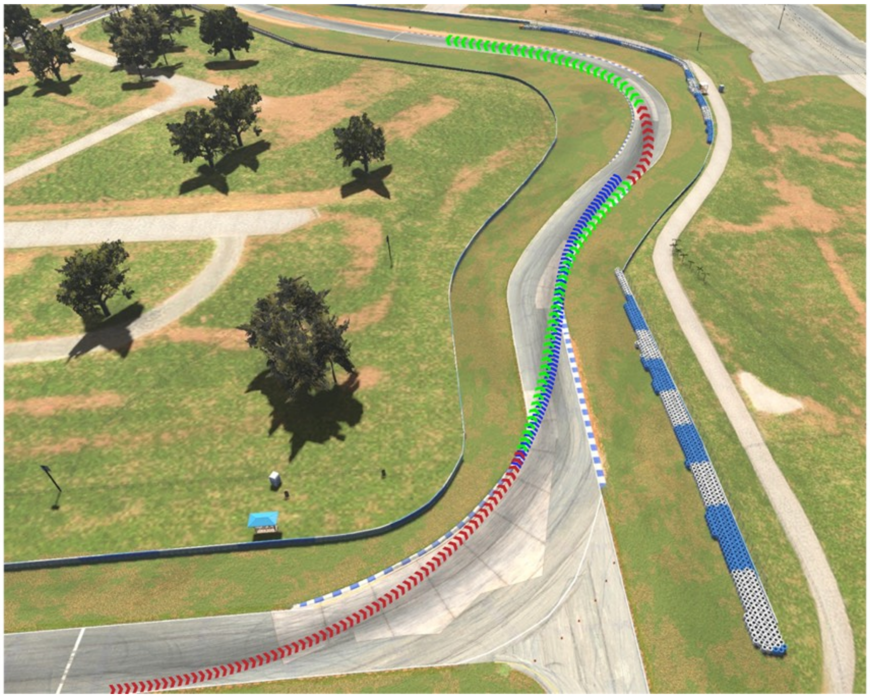


Sebring, Turns 14 and 15

The small, apparently harmless left kink before Turn 15 at Sebring traps many drivers into not using the whole track where it really matters: the braking zone into the right hander. If you try to keep the car close to the left side of the track before the kink, you won't have the grip to place the car on the white line right before braking (blue line). To solve this problem, stay a little wide just before the kink, so you can "late apex[1]" it and stay on the left (green line).

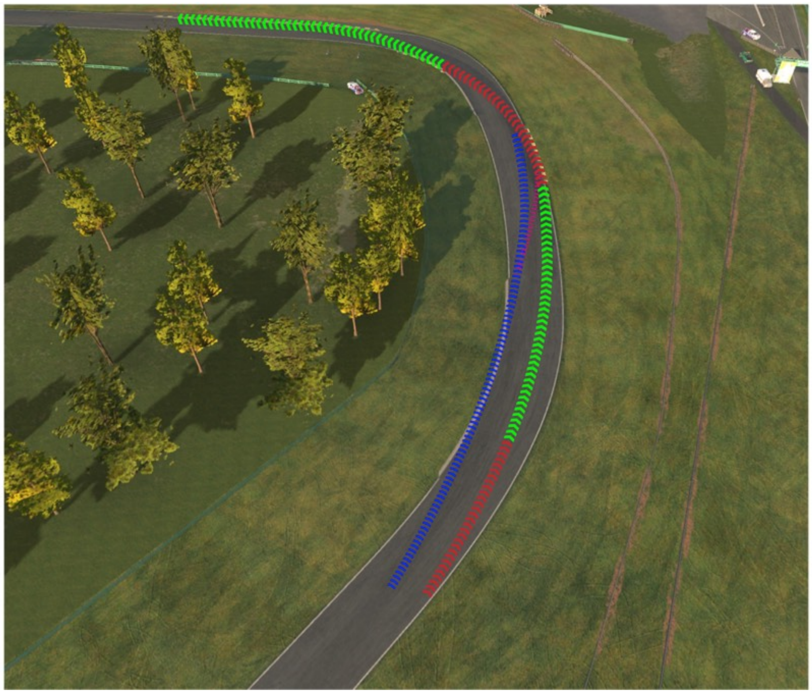


> Turn 2, also at Sebring, is a very similar kink to corner complex. Avoid driving the blue line!



Sebring: Turns 3, 4 and 5. Avoid driving the blue line!

Turns 3, 4, and 5, still at Sebring, also deceive you into driving the wrong line right before the most important corner of the sector, since it leads into a straight. As you can already imagine, being aware of these deceiving corners might give you a huge advantage on this racetrack!



Virginia International Raceway, Turns 2 and 3

The example above at Virginia International Speedway is a variation of a deceiving corner, this time with both the kink and the corner going the same direction. In this case, falling into the trap means trying to apex the kink, which destroys your line into the actual corner that requires braking. If you drive the blue line, by the time you realize you have to open up to do the actual corner, it’s too late. If you try to open up anyways (purple line), you’ll start braking with the angle completely wrong, pointing many degrees to the outside, and drastically decreasing braking and cornering performance. The solution is to “miss” the apex of the small kink to ensure you have the right line for the second left hander (red and green).

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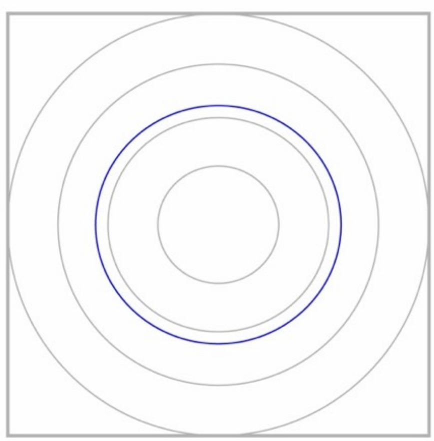
1 Late apex means hitting the inside of the corner at a later stage, which in the case of the example above allows for a wider entry for the next left hander.

9

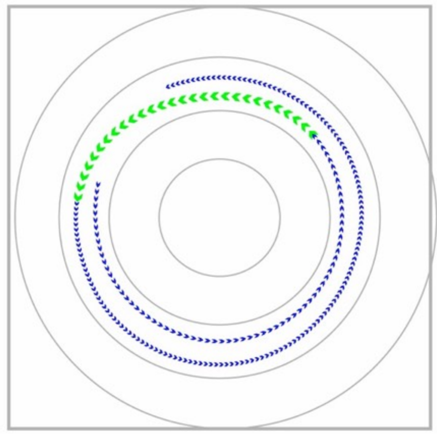
MAXIMUM ROTATION POINT (MRP)

At this point I have mentioned the "Maximum Rotation Point" several times. In this chapter, I will explain what I am referring to.

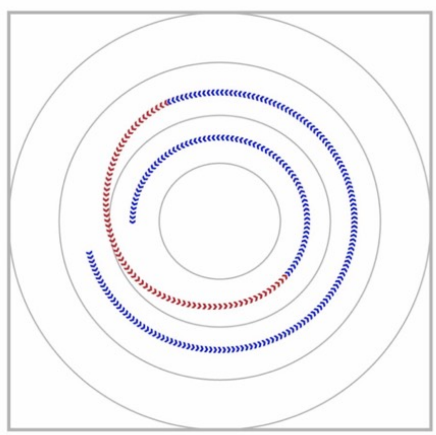
If we drive a car at a fixed speed while rotating as much as the car can handle without understeering too much or oversteering into a spin, right on the limit, the car will produce a fixed-radius circle:



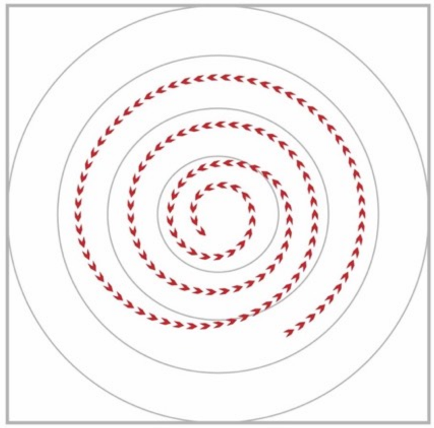
As you can see in the image below, if we increase the speed and then maintain it, the car will start doing a bigger circle. The higher speed means it won't be able to maintain the same rotation from before, creating an increasing radius while accelerating (green), and a new fixed but bigger radius when maintaining the new higher speed (second layer of blue):



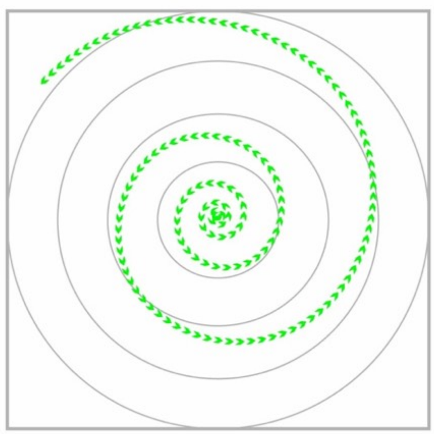
If we decrease the speed and then maintain it, the car will start doing a smaller circle, since it will have more capacity to rotate.



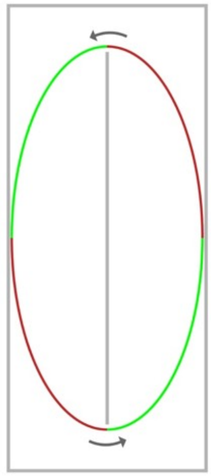
If we decrease the speed at a consistent rate, the car will progressively turn more, creating a closing spiral.



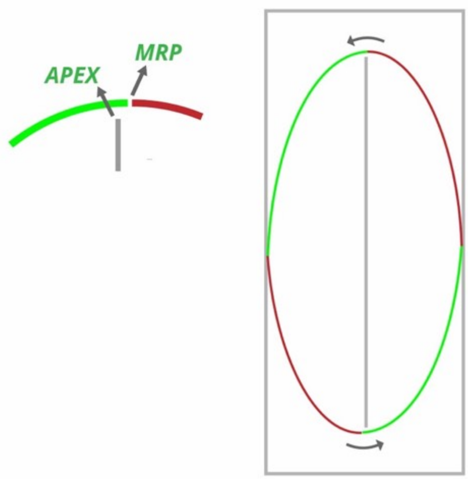
If we increase the speed at a consistent rate, the car will progressively turn less, creating an opening spiral.



In corners where deceleration is required, the rotation should then reach its peak at the minimum speed. This creates something like an ellipse. In this next example, the vertex of the ellipse matches the inside of the corner, or apex.



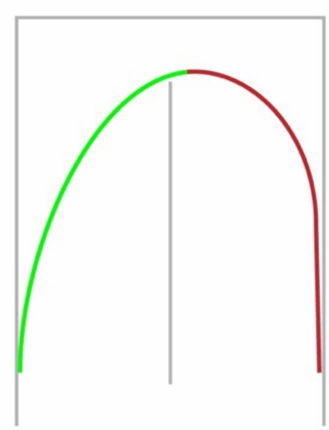
Racecars are much more efficient in deceleration than in acceleration. This means we spend less time braking and more time accelerating. To maximize exit speeds and compensate for this behavior, we should start accelerating a little earlier than the geometric ideal line. Then, our ideal racing line looks like this:



Knowing this, we have two very important points to discuss. I first one is the apex. The apex is the inside limit of a corner. While I describe the concept of the apex in this way, others might describe it as the place where you start accelerating. I find this confusing. That's why I created a distinction between the apex and the Maximum Rotation Point. This is one of the most important concepts I've developed in my coaching career.

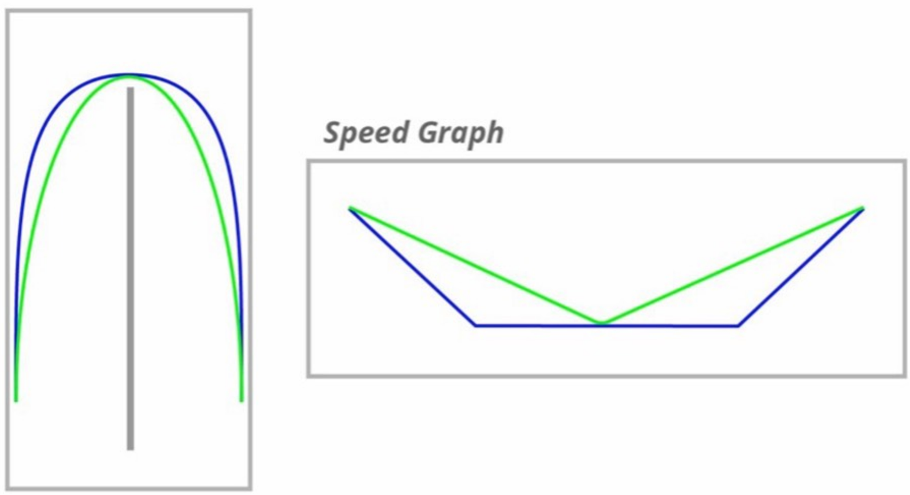
The Maximum Rotation Point is the place where you reach peak yaw rate. Yaw rate is the amount of rotation per second that the car generates, normally measured in degrees per second (deg/s). In simpler words, the MRP is the point where the car is turning the most. It should also be the minimum speed point. The car rotates the most when slowest. While it might seem obvious to some, based on my experience coaching so many drivers, including some high-level competitors, it's not. It becomes less obvious *in practice*. The reason it is not obvious is because of the confusion between the MRP and the apex.

The Maximum Rotation Point is *not* the apex. Again, the apex is the physical inside limits of the corner.



Here is an example of a late apex approach. In a late apex approach, you accelerate earlier, which means the distance between the MRP and apex is bigger (and the MRP is before the apex).

Why should we have a well-defined Maximum Rotation Point in a corner? It allows you to brake later, and accelerate earlier, both at the same time. Without a clear MRP, there is a big chance we'll end up reaching a fixed amount of rotation and speed, staying there for a while, not knowing what to do mid-corner, maybe accelerating a bit (half-throttle), and scrubbing the fronts waiting until we feel confident to accelerate. This mistake is what I call a **Maximum Rotation Line (MRL)**, where the driver is confused and just waits for the feeling that they can accelerate while keeping the yaw rate fixed. Drivers who make MRLs are most likely losing time on early entry and late exit. Just remember: if the car is decelerating, you *must* get more rotation out of it. Always.

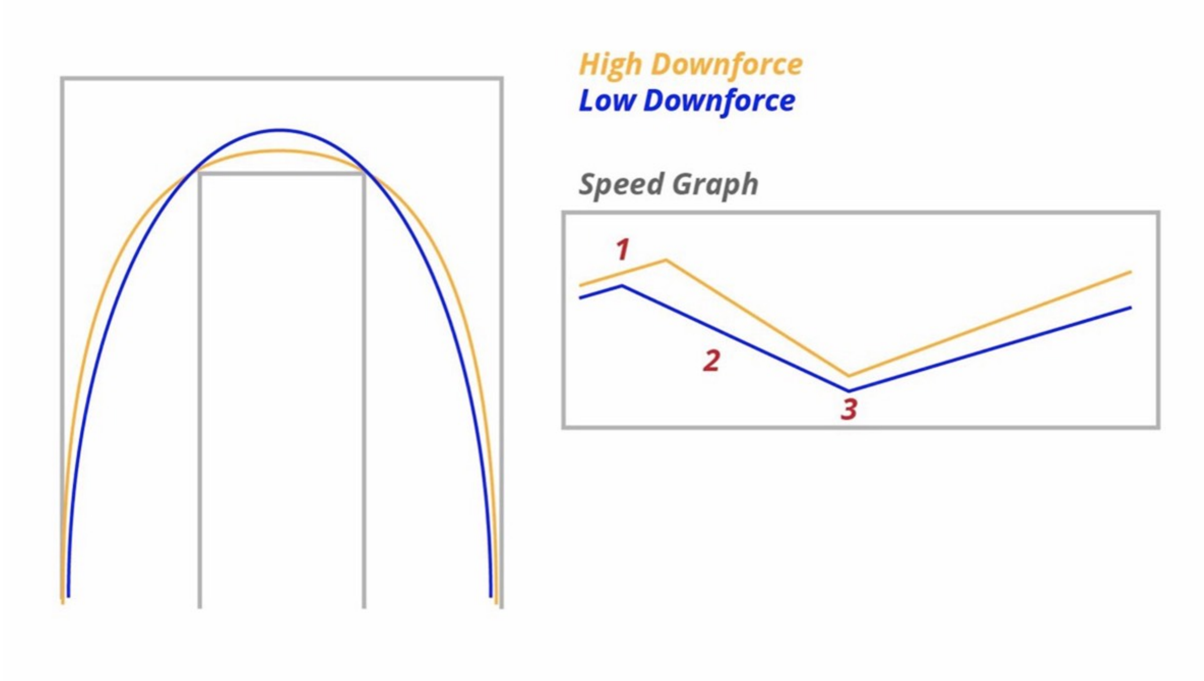


Blue: Not very well-defined Maximum Rotation Point (an MRL). Green: Well-defined Maximum Rotation Point.

The Maximum Rotation Point helps to identify the differences more clearly between a V-shaped approach versus a U-shaped approach.

A V-shaped approach (imagine a more pronounced ellipse) makes the car turn in much more progressively. The transition from braking to turning is slower in this approach and the rotation is much higher at the slower speeds.

A U-shaped approach, however, is suited for high-downforce cars. Here, the rotation does not start as much progressively as it does linearly, since the extra downforce adds some extra cornering capability at the higher speeds to compensate for the natural V-shape tendencies that inertia causes.



> Note how the difference in speeds between the yellow and blue line is biggest at high speeds (1), but smaller at the low speeds (3). This is due to downforce being more effective at high speeds.

The biggest benefit from the MRP is being able to simplify the approach to and learning process of new corners, as well as perfecting the ones you already know. When learning a new track, you can simplify everything into only two points: the braking point and the Maximum Rotation Point. Knowing you'll build up your rotation to a peak at the defined MRP, you'll naturally find your turn-in point, and the exit of the corner will just be a consequence. By treating the exit as a consequence, you can judge how well-placed your MRP was, and then make adjustments to it.

Before we go into more detail on the Maximum Rotation Point, here are some extra tips:

- The Maximum Rotation Point should be the Minimum Speed Point.
- Because of this, the MRP is also the Throttle Application Point.
- Generally, the Maximum Rotation Point is placed at the End of Braking Point (EOB) (where you stop braking and start accelerating). The exception is when you are driving a car that

oversteers on entry and you can’t trail brake all the way until the throttle application, which means you are coasting for a while.

- The Maximum Rotation Point is the peak yaw rate of the corner.
- Look for the MRP as early as possible when learning a new car/track combo. Start with the lower speed corners, then move up to finding MRPs at higher speed ones. Feel the limit of grip when finding rotation at the minimum speed. This will give you valuable information that will allow you to find the ideal line and speed in that corner much quicker.

Remember that the Maximum Rotation Point is just the climax. Although it is a point, the build up to it starts as soon as you turn into the corner. Don’t relax between turn-in and the MRP!

10

BOUNCING OFF THE APEX

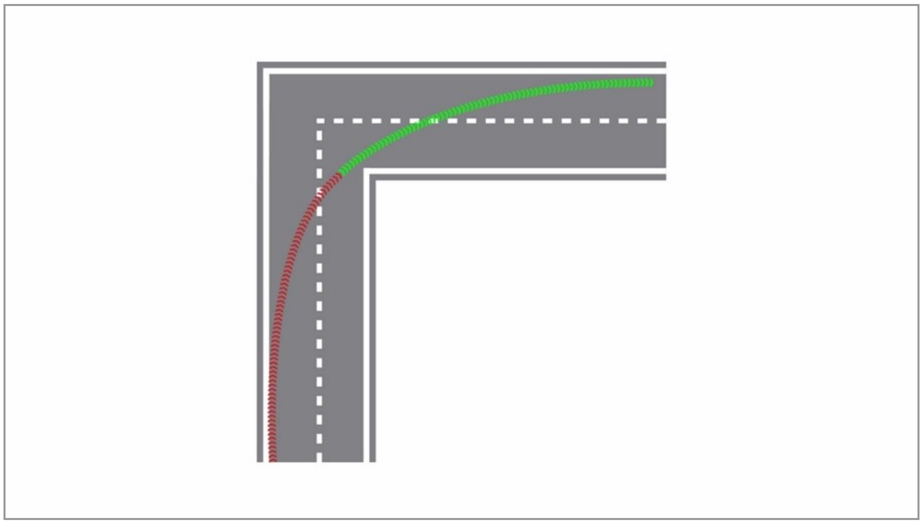
Being aware of the Maximum Rotation Point idea inherently makes you try to rotate the car more. Its very name persuades us to reach that peak rotation, which means we're looking for the lateral grip limit mid-corner.

If you turn in at the right moment, at the right speed, with the right trail braking, you'll spend 100% of the corner rotating the car as much as you can. This means you'll remain on the best racing line, and touch the inside track limits perfectly, all while forcing the car to turn more and more.

If you turn in a little too late, no matter how much you force the car, you'll miss the apex, either through understeer or oversteer and corrections. You'll end up trying to force the car through the whole corner, even though it won't be the fastest way through it.

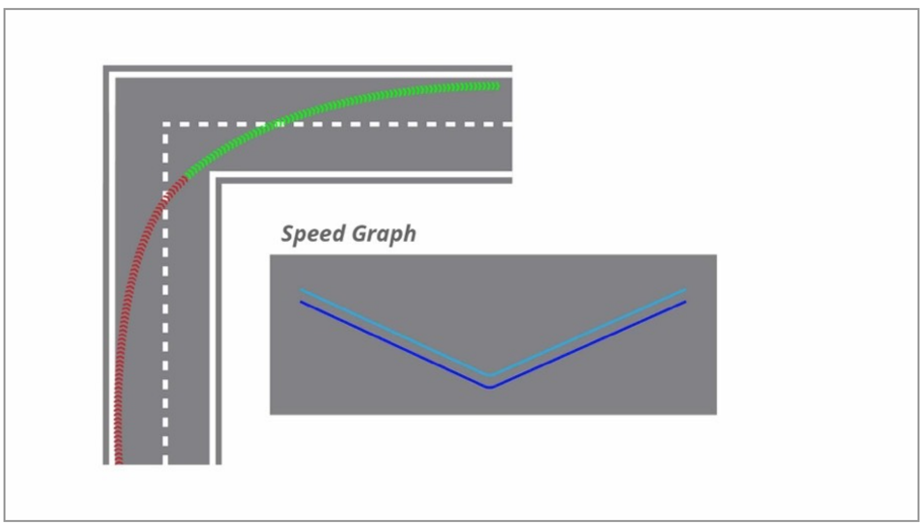
If you turn in too early or too slowly, something interesting happens. So many drivers I coach have this problem. It's common because it's a comfortable mistake that makes you feel good.

In an easy corner like in the image below, you know the racing line. You know you should brake in a straight line and then turn into the corner while trail braking, accelerating slightly before the apex.



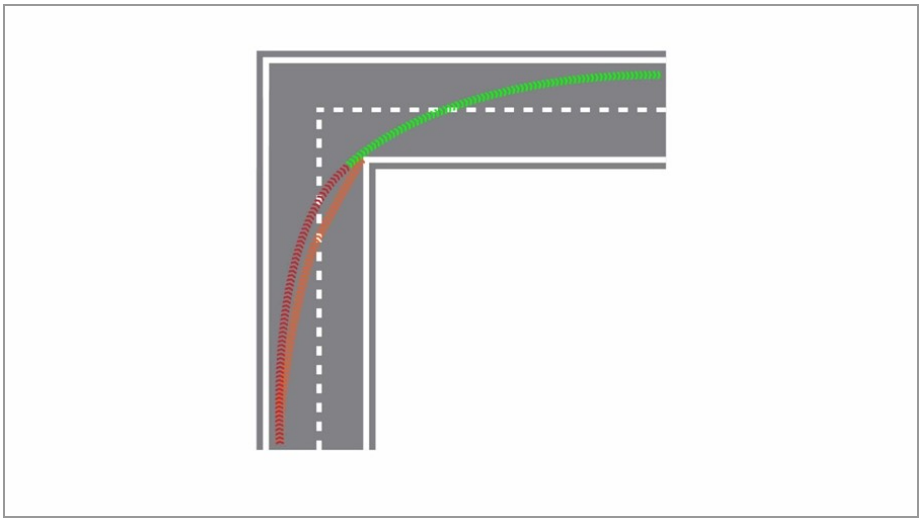
Imagine that you are just a little under the optimal speed to take the corner. What do you do? Two courses of action are likely.

The first is doing nothing different, really. You continue to drive the racing line, but you are under the limit. This is what a driver that **Drives the Line** will do.



> If you are doing the perfect racing line but carrying a lower speed (darker blue), you can lose a lot of time without noticing. Remember the mentality of hustling the car and always trying to extract rotation from it!

The second is that you'll turn in, asking for rotation, but you realize the car turns a little more than necessary so you relax the steering a bit to ensure the car is still on the ideal line. This is what the driver that **Drives the Car** will do. This is ultimately more useful than the first option, if done properly.



A driver that consistently forces the rotational capability of the car (orange line), when slower than ideal, will extract more rotation than necessary, correcting the direction deeper into the corner so to not hit the inside.

Both options will be slower. In both, you are carrying less speed into the corner! The second option, though, will be more useful for us in this chapter, since it is the best way to identify the problem.

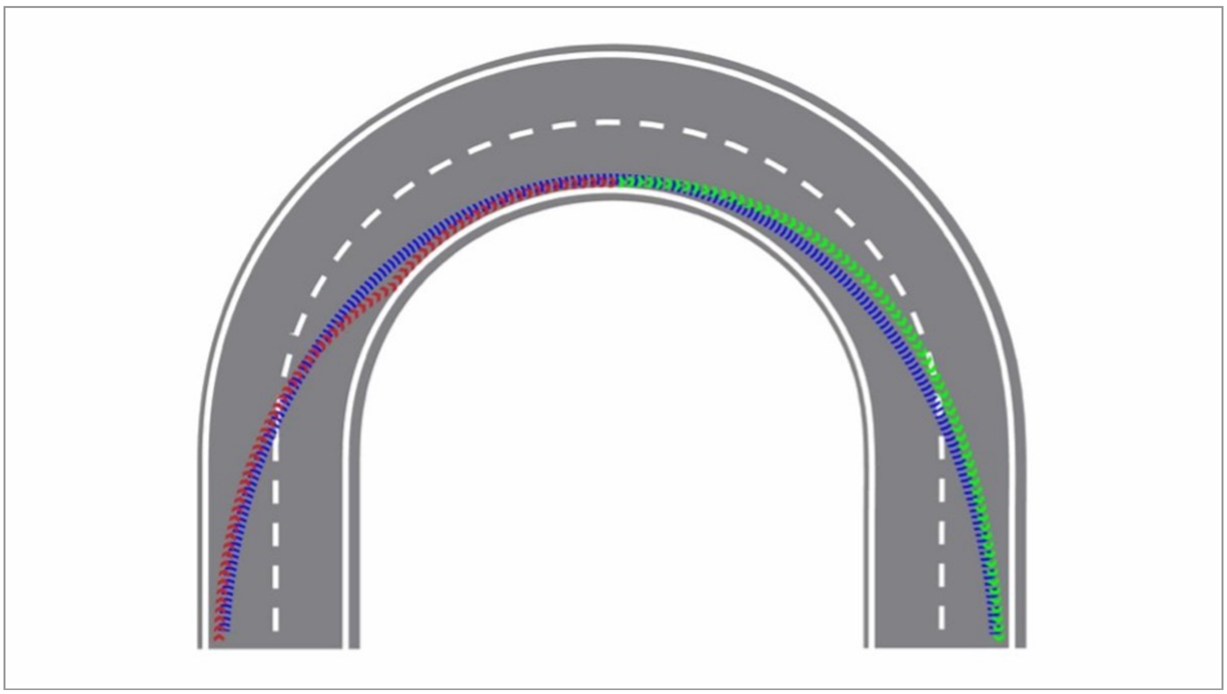
The problem with carrying less speed is that it makes the corner much easier. You have some extra room for keeping the car on the ideal racing line. This feels comfortable. Driving the car a little slower guarantees that you are not going off track or getting off the racing line. If you don't want to do that, and if you want to go as fast as possible, how can you quickly identify this problem and solve it?

Here's where the "bouncing off the apex" idea comes into play. Always rotating as much as possible, at all stages of a corner, is the key to ensuring you are using all four tires to their limit. But, if you are a little slower, the car will give you more rotation than you need for that corner, as per the second course of action.

As soon as you notice you are rotating too much and going towards the inside, make a correction with the steering. Straighten it out to go back to the ideal path. Then turn again.

There's nothing further you can do in that corner. You carried less speed into it. You may compensate to get a slightly better exit and lose less time, but that corner is not ideal anymore. What you *can* do is remember what the car did at that speed. Remember how it felt and how the rotation was too easy. Then, try to carry slightly more speed into the corner on the next lap.

Bouncing off the apex refers to turning in too early or too slowly, putting you on a path where you'll hit the inside of a corner and get stuck there. This completely kills your peak rotation.



"Bouncing off the apex" (red) happens when the driver slowed down the car too much and the car can rotate more than necessary. The ideal line is in blue.

A perfect Maximum Rotation Point is built from the very beginning of a corner, adding rotation until you reach the acceleration point. If you lose that rotation and try to generate it again on the second half of corner entry, you won't recover the lost rotation and the time from that correction. Although we say the MRP is a specific place, it is truly the peak of something that builds up since the turn-in.

My advice is to try to bounce off the apex! Turn more and test how much rotation is available, even if that means going where you don't want to. This will clearly show you if the car is too slow. You'll learn the speed threshold for that corner and make corrections more quickly.

Over slowing and driving the perfect racing line is likely to be slower than carrying too much speed and missing the apex a little but driving on the limit during the entire corner.

11

DOUBLE APEX: HIGH DOWNFORCE VS LOW DOWNFORCE

A double-apex corner is one where the ideal racing line touches the inside limit of the track twice. There are two types of double apex corners. The first type is two separate corners, like a double-right or double-left, that are close enough that you don't have time to accelerate in between them. Here, you merge the ideal racing lines into one single deceleration, one single MRP, and one single exit.

Laguna Seca – Andretti hairpin

This type is easy to spot, especially when the corners are kind of square. The natural line already sends you into a double-apex approach, where you hit the inside limits twice.

The second type is more difficult to spot. These are long corners that appear to have a fixed radius or a single apex.

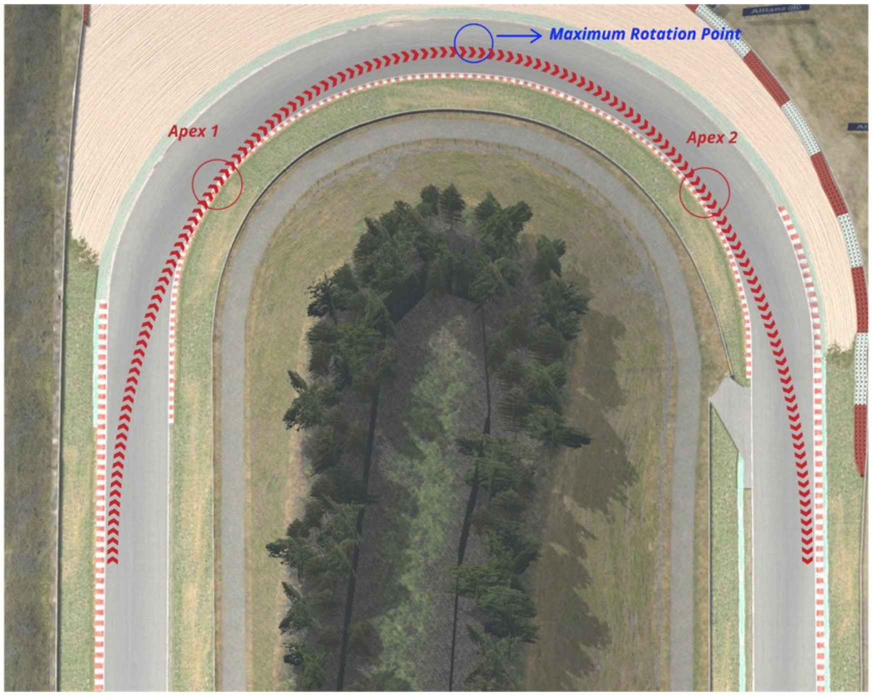
Bruxelles corner at Spa-Francorchamps

Of all types of corners, this type is most likely to encourage you to take the wrong approach. This is a corner where most drivers bounce off the apex for a long time, losing a lot of lap time on entry *and* on exit.

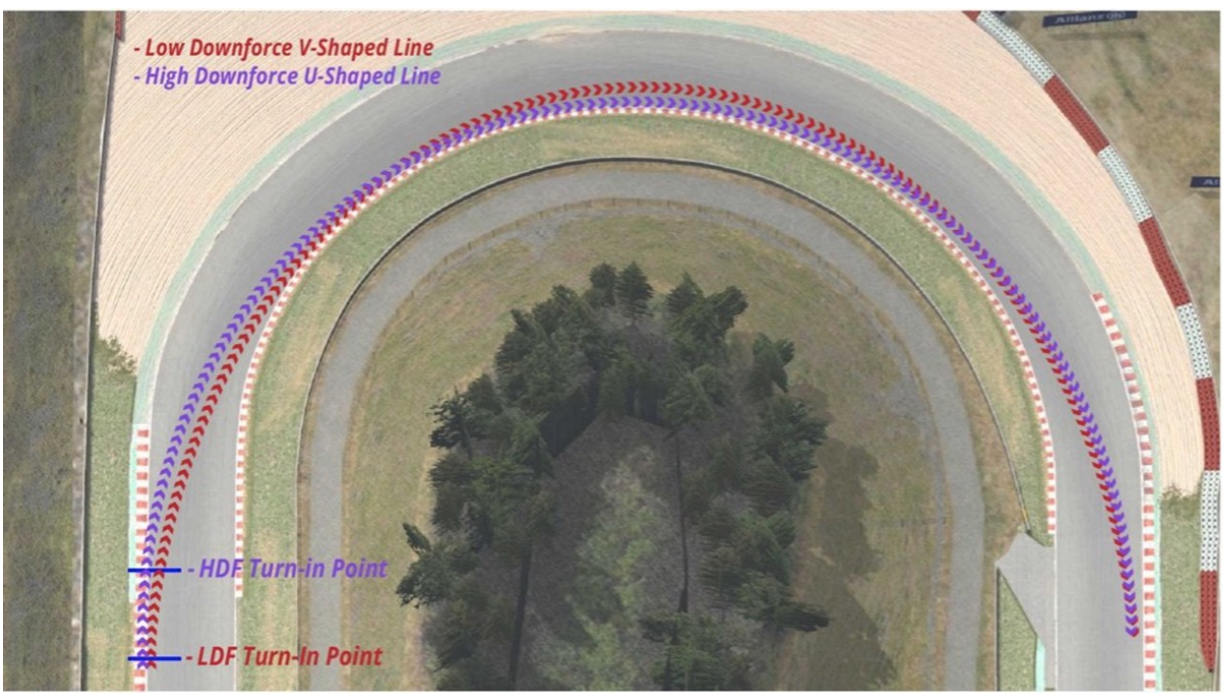
I will break this down. In a short 180-degree corner, or a hairpin, you would brake in a straight line to slow down the car, and then have lots of rotation in a short amount of time.

Circuit Gilles Villeneuve – Hairpin

In a long 180-degree corner, like Bruxelles, you'll spend a lot more time in the corner, which means your braking duration will be higher. If you are braking for longer, you can carry more speed into the corner by braking *less* while making the turn. Because of the V-shape nature that emerges from trail braking, the ideal line will end up touching the inside of the track in two different spots.



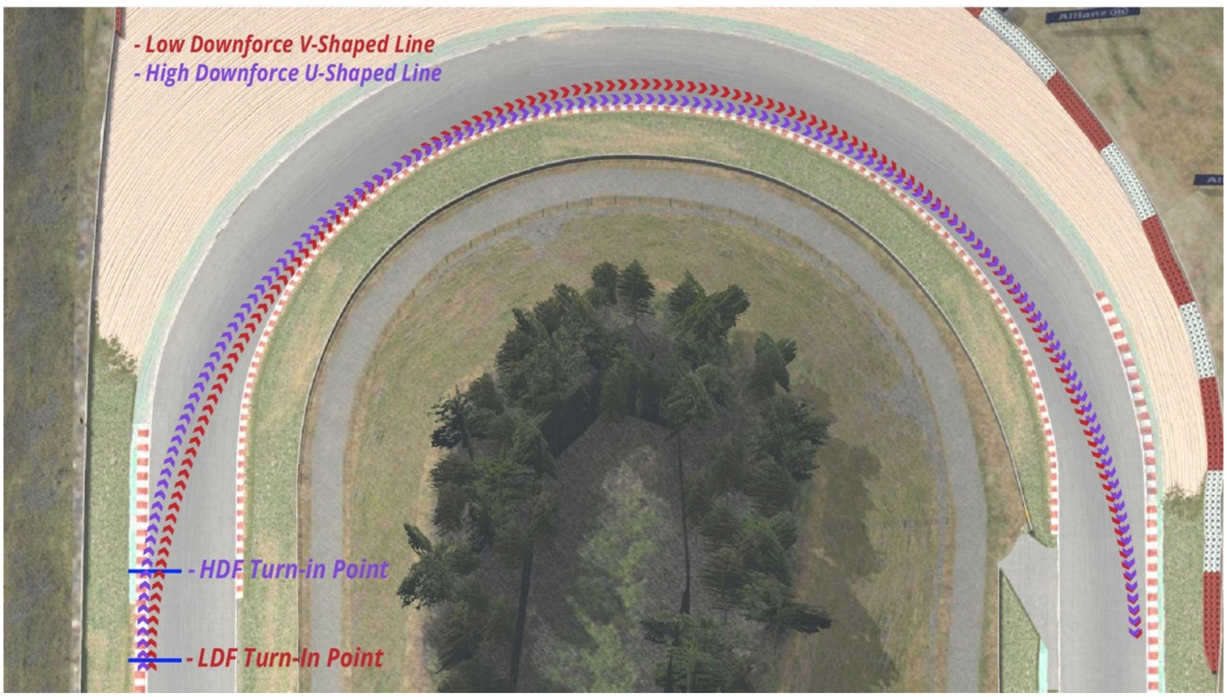
In this chapter, we'll specifically analyze how early to turn, how to figure out the distance between the apexes in such a corner, and what determines the line in a double-apex like Bruxelles at Spa-Francorchamps.



If the car has low downforce, cornering will be very limited at turn-in, increasing progressively towards lower speeds, causing a V-shape line.

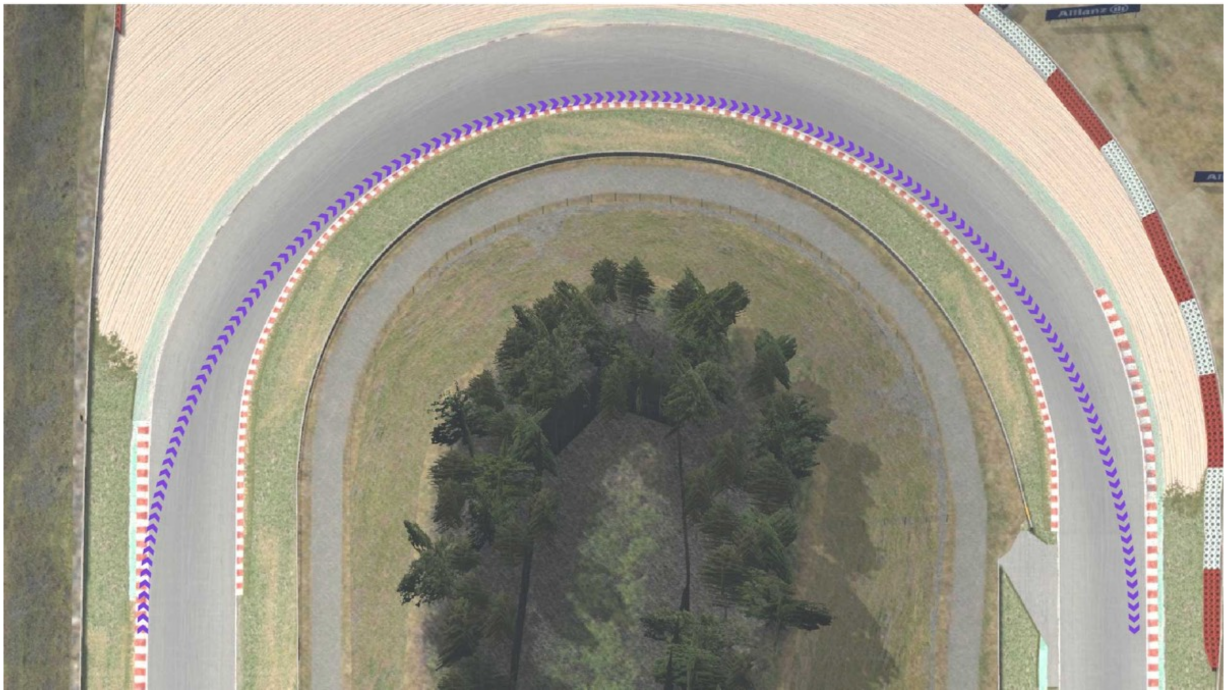
If the car has high downforce, cornering will be more effective on entry compared to the low downforce car, allowing the rotation to increase at a more linear rate, causing a U-shape line.

In the example below, you can see that the Maximum Rotation Point is at the same stage of the corner for both a low downforce car and a high downforce car. The difference lies in how far the MRP sits from the inside of the track.



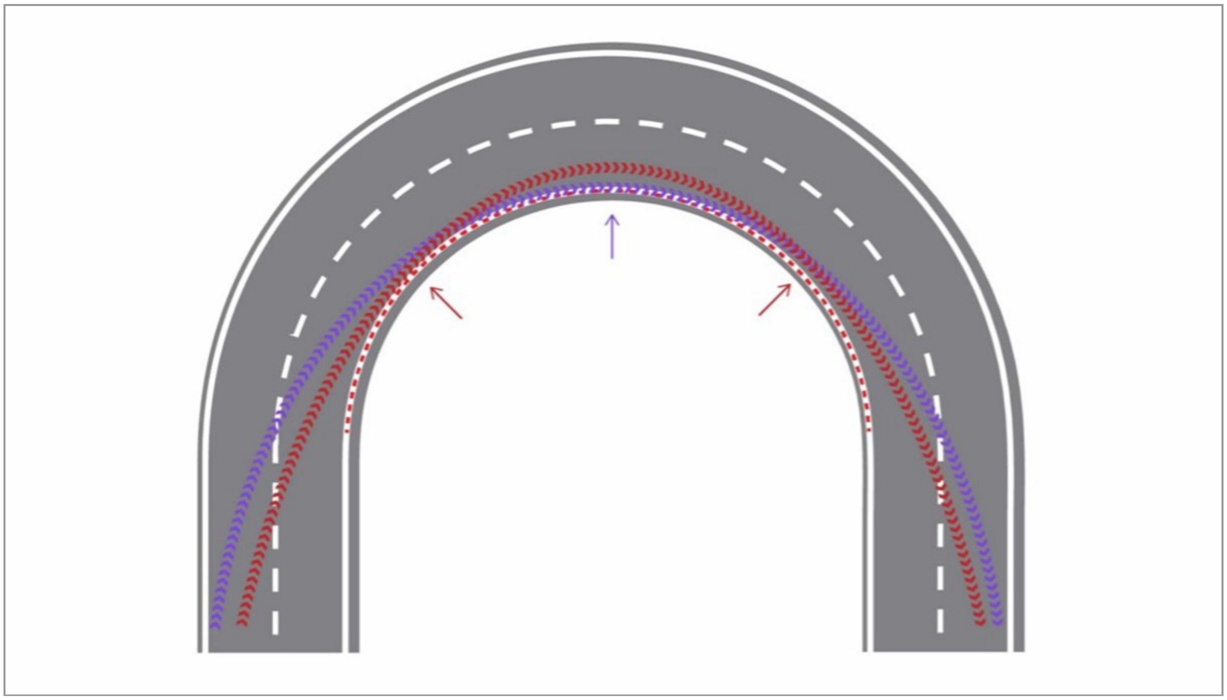
The distance between the apexes is consequently affected by the downforce levels. The higher the downforce, the smaller the distance between the apexes.

Fun fact: if the car has enough downforce, it can convert what would be a double apex in a lower downforce car into a single apex if both ideal apexes meet at a single point. Such phenomenon is rare and happens when the corner is already a very subtle double-apex for lower downforce cars.



If the car has enough downforce, it can single-apex a corner that would be a double-apex for lower downforce cars.

To summarize:



Low downforce (red) versus high downforce (purple)

In low downforce cars, a double apex will have:

- Earlier turn-in,
- A more elliptical line,
- More progressive/exponential steering input,
- More trail braking into the corner, and
- Bigger distance between the apexes.

In high downforce cars, a double apex will have:

- Later turn-in,
- A more circular line,
- More linear steering input,
- Less trail braking into the corner, and
- Lower distance between the apexes.

12

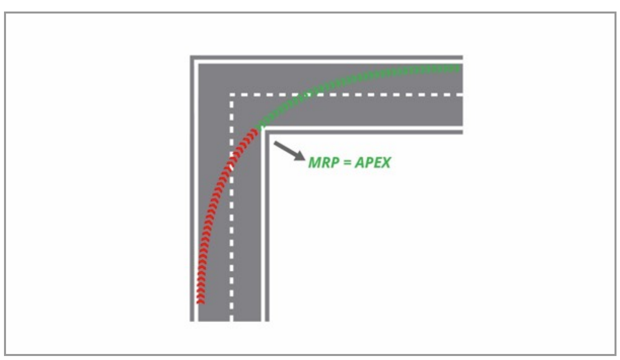
MAXIMUM ROTATION POINT VS APEX

Earlier we discussed the distinction between Maximum Rotation Point and apex. Let's go into more detail. We will discuss the distance between the apex and the Maximum Rotation Point in single apex corners, which has been alluded to before.

Let's analyze the single apex corner in this image and the possible approaches to it. The ideal approach will depend on many conditions, like car, setup, and even racing situations.

Example One

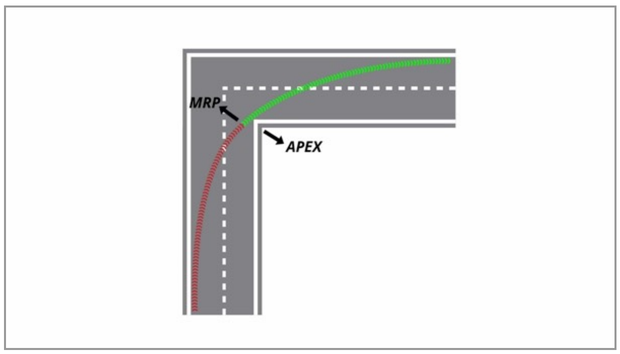
In this first example, the apex and MRP are practically at the same point.



This represents the ideal geometric line, but since racecars decelerate more quickly than they accelerate, we want to start accelerating a little before the apex to generate more speed at the exit.

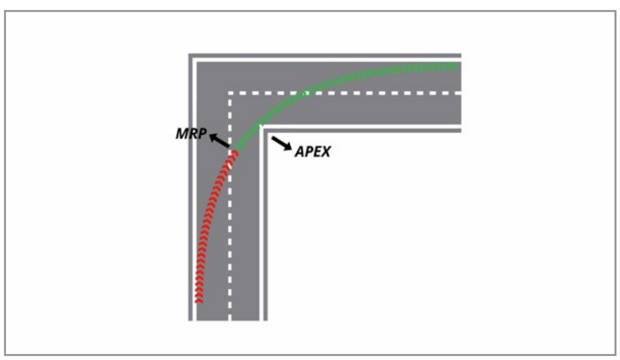
Example Two

In the second example, there is a small distance between the MRP and apex. This is the most common approach, where the difference between braking efficiency and acceleration efficiency are compensated, allowing for better exit speed.



Example Three

In the third example, we have an aggressive approach, focusing on the best exit possible, but at the cost of losing time on entry.



A very common mistake among beginners is to turn in and accelerate right away, trying to do the entire corner while accelerating. Be careful! This induces a lot of understeer. Try to rotate at least 50%, as a baseline, of the corner while on the brakes!

The approach in the third example could be an ideal way to do the last corner before starting a qualifying lap, for example, since the time of the current lap does not matter, and the next lap will start with a slightly higher speed at the start/finish line.

Summary

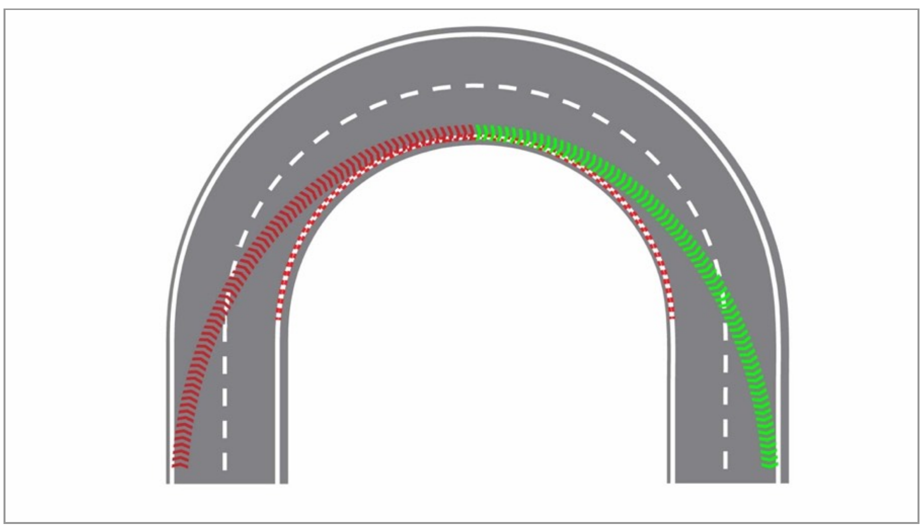
A late apex should mean early throttle application. There is often confusion even among high level drivers and coaches when describing the relationship between the apex and the throttle application point. I’ve heard people say that the apex is where you accelerate. In the case where you are hitting a late apex to get a better exit though, you accelerate earlier.

You should never accelerate after the apex. The Maximum Rotation Point (which, as mentioned before, is also where you will start accelerating) should always be before the apex. Sometimes it might be at the same spot, but never past.

13

EARLY APEX VS LATE APEX

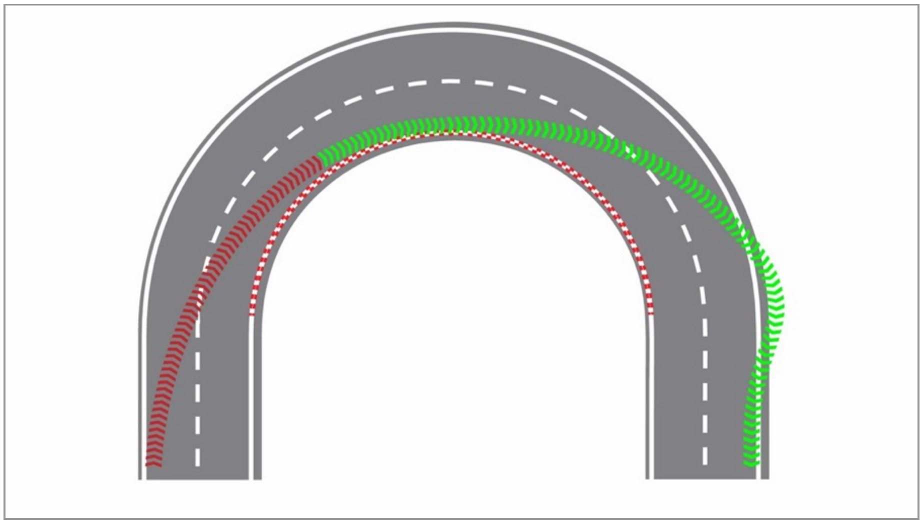
In this chapter we will explore when a driver should take a late versus an early apex. Let's go back to the geometric racing line for reference.



In this example, the Maximum Rotation Point and apex are at the same point.

Since deceleration happens more quickly than acceleration, we should accelerate slightly earlier than the apex in almost all corners. When drivers first hear about this, many end up accelerating way too early.

If a driver accelerates too early, they are likely to drive off track after the corner.



Ideally, you want to accelerate when the car has rotated *at least* 50% of the angle of the corner. For example, in this 180-degree corner, you want to have rotated at least 90 degrees before you accelerate. If the car is pointing away from the direction of the corner exit, the throttle will create conflicting forces, making the car push wide through understeer or oversteer. The same would apply for braking. If you are still trail braking after the 50% mark, you are creating forces against the direction of the corner and losing a lot of time.

If the apex is later in the corner, our MRP will move backwards. If the apex is 51% of the way through the corner, for example, the MRP would then be at 49% of the way through the corner. This means we'll reach peak rotation and start accelerating slightly before the apex, which will give us a better corner exit speed. Such a subtle change would still be considered early apexing.

High speed corners are mostly faster when early apexing. Consider the MRP at 49% of the corner and apex at 51% of the corner as references for early apexing.

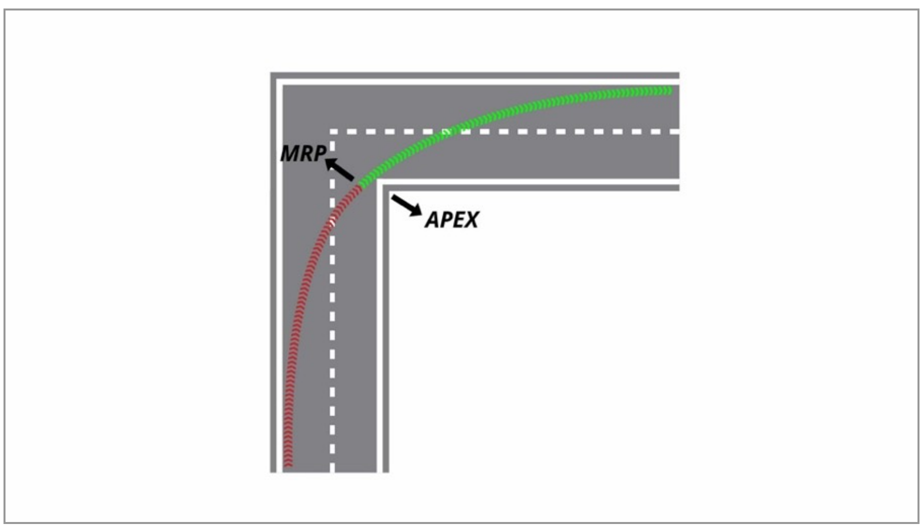
Medium speed corners are mostly faster when doing a slightly later apex. Consider the MRP at 47% of the corner and apex at 53% of the corner as references for a slightly later apex.

Low speed corners are mostly faster when doing a more aggressive late apex. Consider the MRP at 45% of the corner and apex at 55% of the corner as references for a late apex.

These examples are great for corners that are isolated from others (that have a straight before and after). In reality, you will always be surrounded by other corners, which will be another factor in deciding how to approach each corner. If you have a long straight after the corner, for example, you might benefit more from a late apex, even if it's a medium-speed corner. It might be better to early apex a low-speed corner if there is another corner right away and you wouldn't really benefit from the exit speed. You'll have to weigh your decision factors (speed of the corner + what comes after it) and practice through trial and error. The delta lap time information is your friend in these moments!

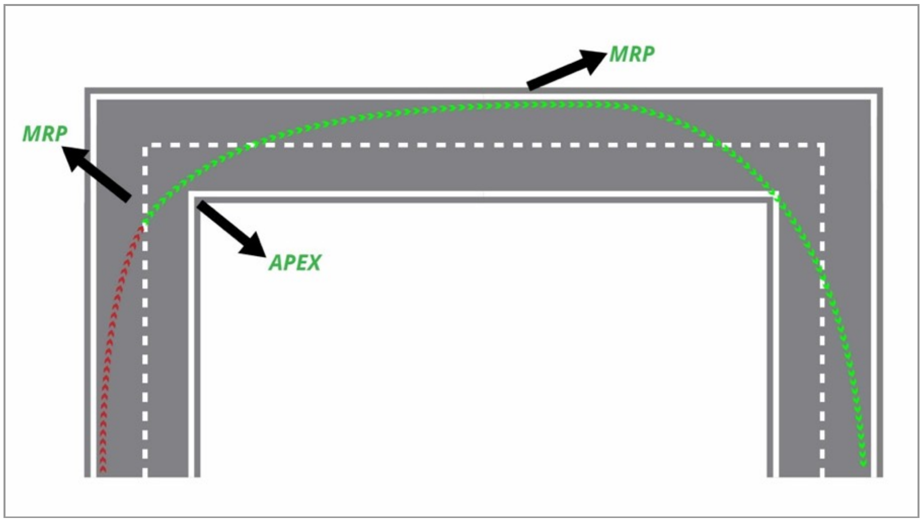
Examples of Maximum Rotation Point Placements

Most corners will have a similar MRP placement: close to the apex, or the inside limit of the corner:



The reason the MRP is placed very close to the apex in these corners is because the car is decelerating, so the rotation keeps increasing until acceleration.

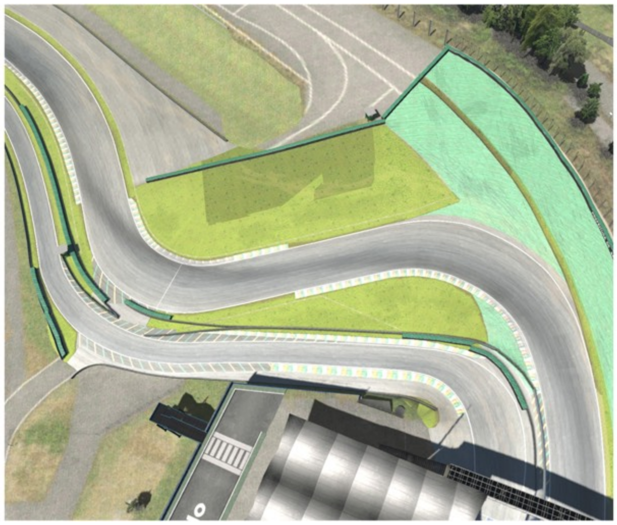
If a similar corner comes right after the first one, the car is already quite slow, meaning no deceleration is needed. Where should the MRP be here?



In this case, the MRP is at the early entry phase, which is not very common. It is also already the turn-in point. This happens because our minimum speed is already at the corner entry since we're just accelerating while doing the second corner. It's common to see drivers turning further toward the apex even though they're already accelerating during turn-in.

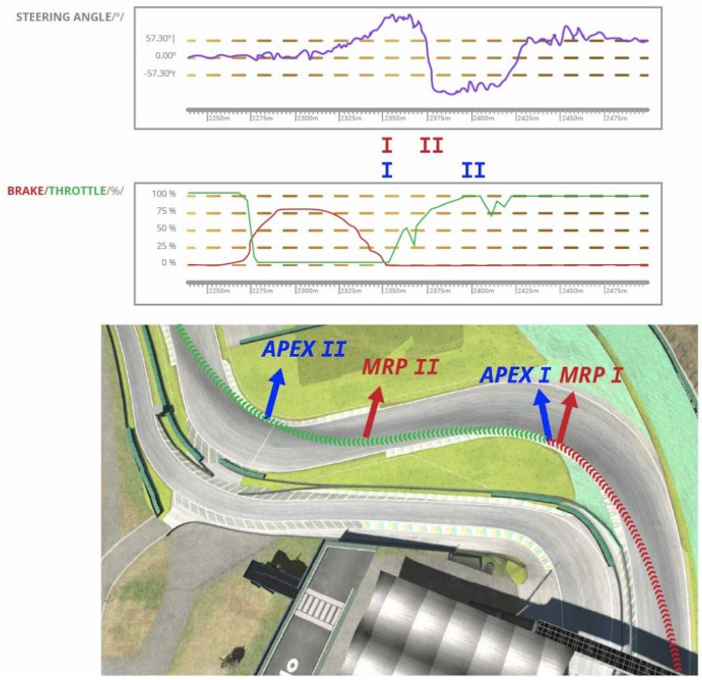
Some corners have weird or unexpected MRP placement. These corners are a common cause of inconsistency and loss of lap time among intermediate and even some advanced drivers.

At the Senna S turn at Interlagos, the MRP is placed as expected in the first apex of this sector: close to the inside limits of the corner on the left. The reason is because that is where the minimum speed is. The second apex, however, is where a lot of drivers get the turn wrong. Since there is a long straight after this sector, it's very important to carry as much speed as possible through the right hander. Because of that, we'll bring the car further to the left and change direction on throttle, not braking again for the second apex.

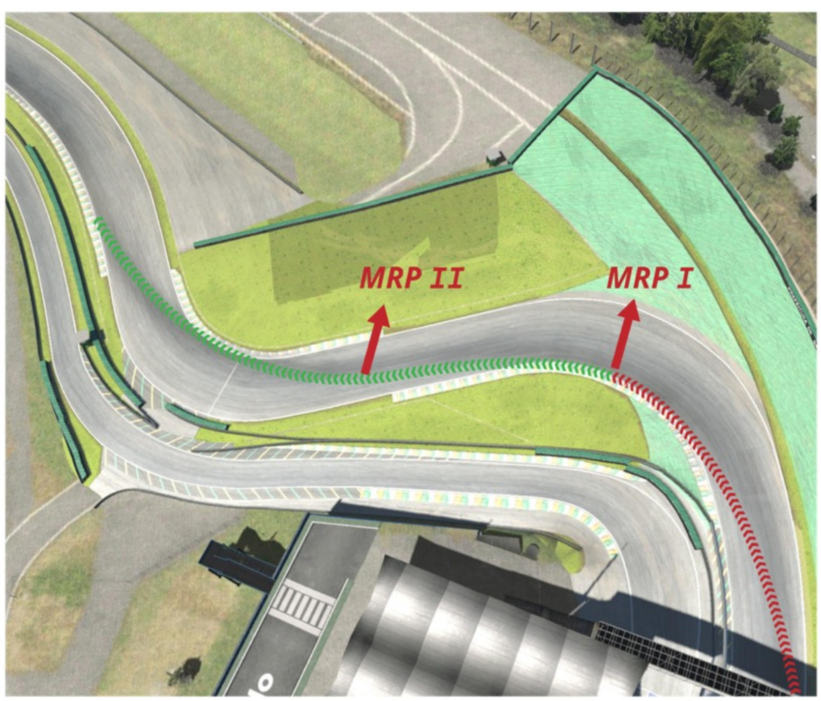


Interlagos: Senna S

Since we are already accelerating, the MRP for the second corner is at the change in direction. We should turn right and reach our peak rotation immediately because we're not braking again. As we gain speed, our rotation should decrease, which means the peak rotation is way before the actual inside limit, or apex, on the right. The MRP placement in this example is an open secret; only really advanced drivers nail it consistently.



The most common mistake in this sector is increasing the steering angle towards the second apex after changing direction, even though we are accelerating there. This would only wear the front tires excessively or cause oversteer and a spin.



Most drivers tend to increase the steering after changing direction, even though they are accelerating. Since the speed is increasing, similarly increasing the steering in that situation is inefficient.

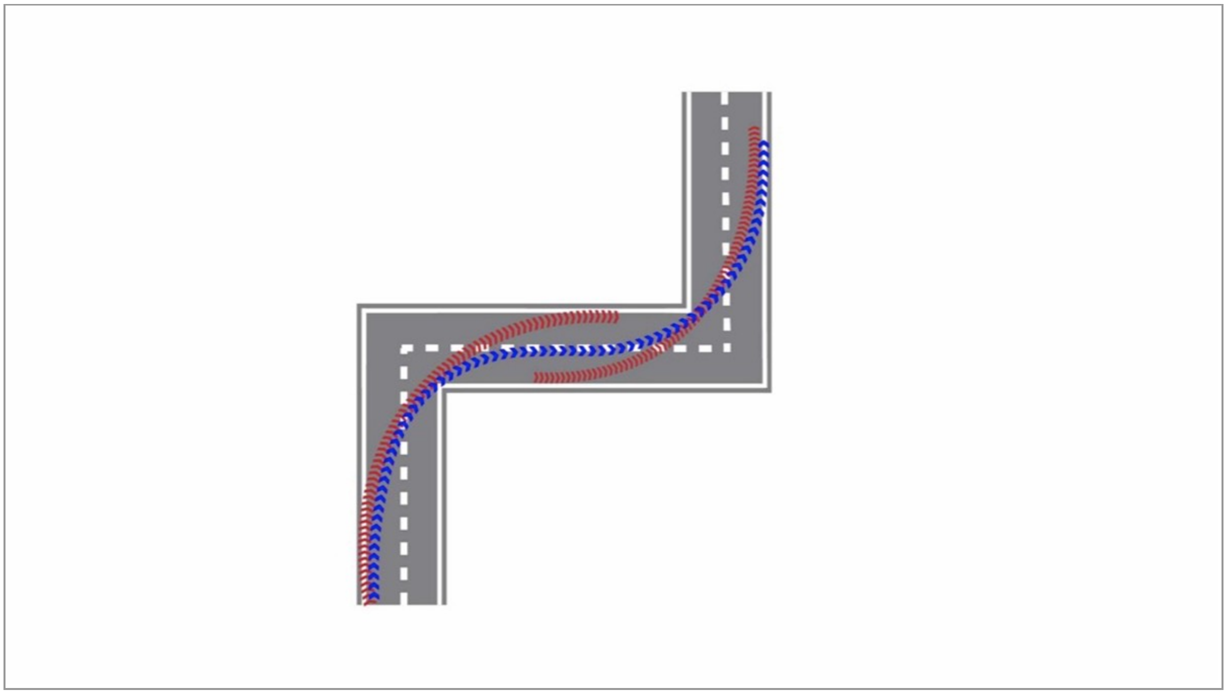
Visit www.suellioalmeida.ca/mrp to watch two sample lessons on MRP placement from my online course, *The Motor Racing Checklist*.

14

COMPOUND CORNERS

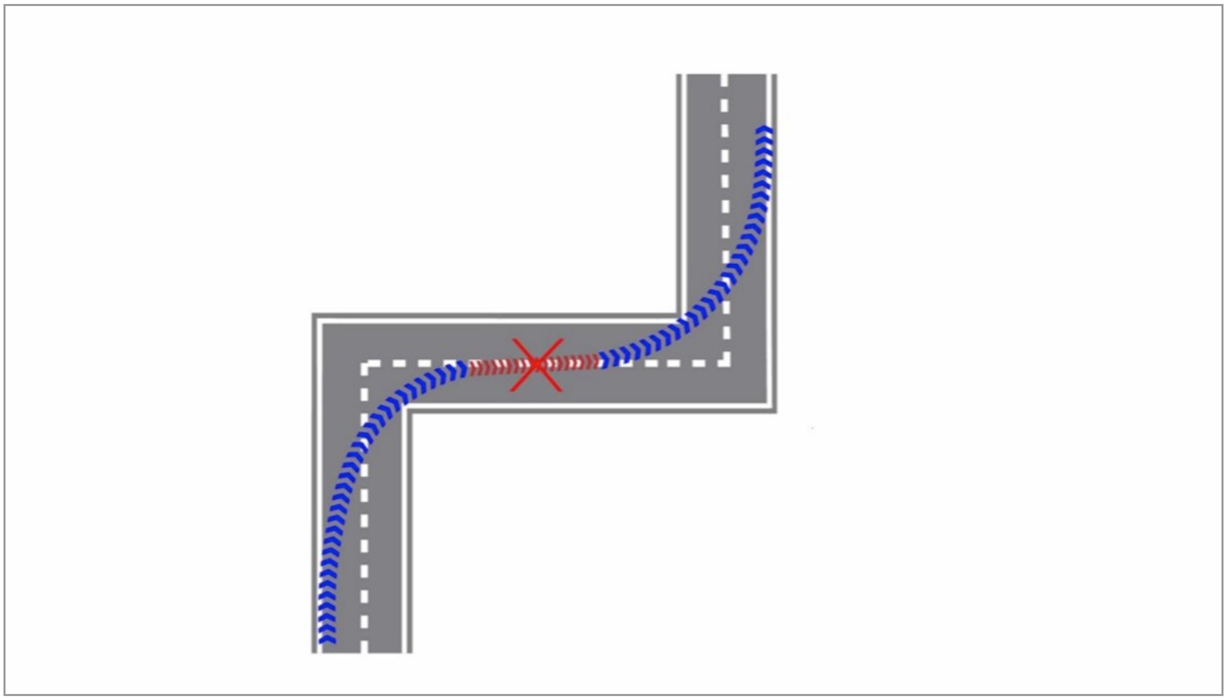
Suzuka Esses

A set of corners is considered compound when the fastest lines of sequential corners conflict with one another and some sacrifices must be made to find the fastest combination possible. Compound corners require you to sacrifice the first exit to have better positioning for the next corner. Where you place your MRP in the first corner will determine the next line, so make sure you plan exactly where you want to accelerate before the first corner to keep the car on a consistent line when practicing compound corners.

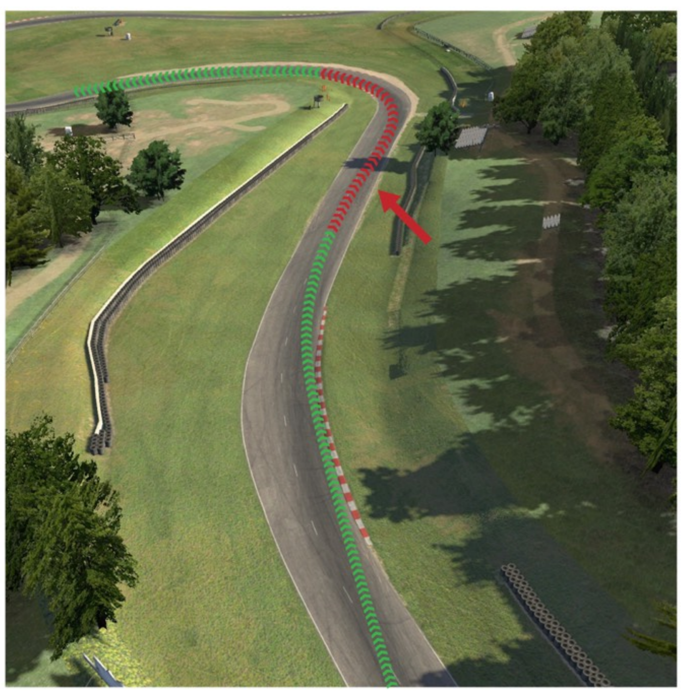


How corners would have been taken in isolation (red) versus how corners blend together as a compound corner (blue).

One of the most important rules for compound corners is to never go straight in between them. You should always be turning as much as possible, on the limit of grip, to prepare the next corner.



The exception to this rule is under heavy braking. In cases where slowing the car down as much as possible is faster than preparing the entry of the next corner, braking fully in a straight line is a better option.



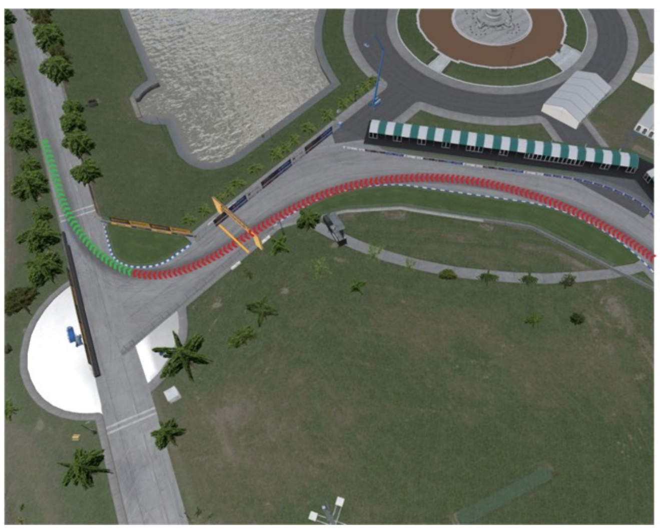
Summit Point – Hairpin

Compound Corners – What to Sacrifice?

Each compound corner has its own context and needs to be analyzed as its own entity. Factors include the corners themselves and what comes after them.

If there is a long straight after a compound corner, it might be worth sacrificing the first corner a little and benefiting from a better exit out of the last one to keep gaining time for longer on the straight. In general, tight corners should not be sacrificed too much in compound corner situations since they impact the lap time a lot more than longer ones.

If there is a long corner that leads to a shorter corner, it's generally better to sacrifice the exit of the long one to minimize the amount of deceleration needed for the short one.



> Detroit (Belle Isle) – Turns 10 and 11. Note how the second corner is tighter, so the ideal line keeps tight, sacrificing the exit of the longer corner to benefit from the shorter one.

If there is a short corner that leads to a longer corner, it's generally better to not sacrifice the short one too much, since we'll have enough time to decelerate, and maybe double apex, in the longer second corner.

Interlagos, Pinheirinho. Note how the second corner is longer, so we try to benefit as much as possible from the first shorter corner, without losing too much time on the longer left hander afterwards.

Compound Corners – Adjustment Methods

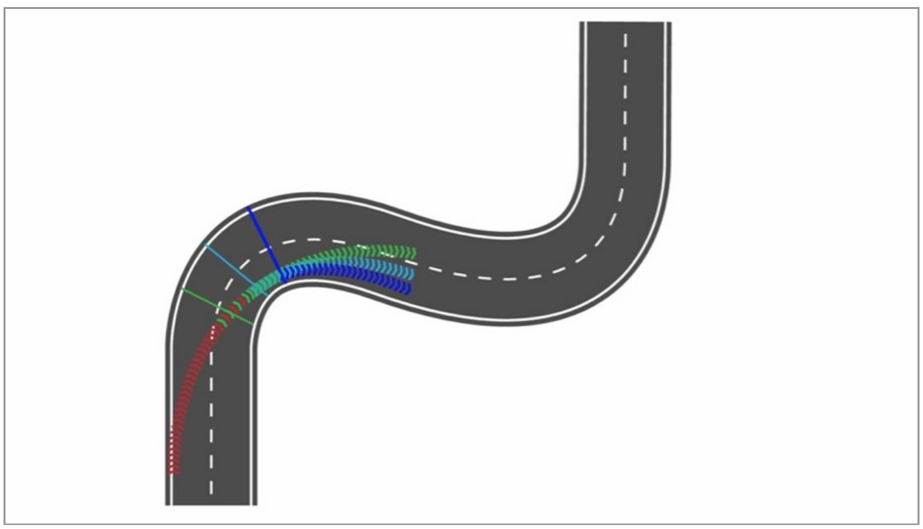
In a regular corner, we have:

1. Positioning and Angle
2. Braking Reference
3. Turn-in Point
4. Maximum Rotation Point
5. Exit Line (Consequence)

The exit line is the part of the corner where we have the least amount of control, which is why I call it a "consequence." In compound corners, that consequence debuts in the initial conditions of the very first corner, which shows how important it is to nail the four first points on the first corner.

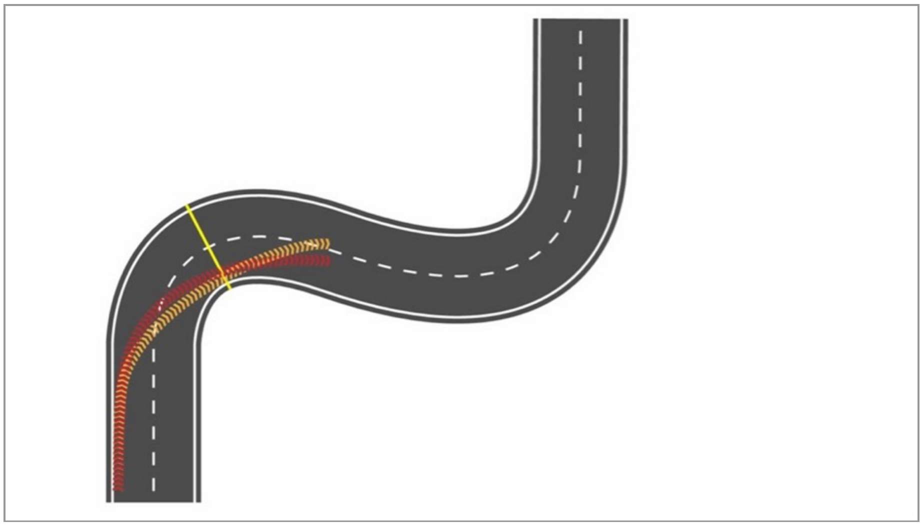
More specifically, the MRP in the first corner will lead to specific positioning and angle of the second corner, which repeats the cycle. If there is a long straight line between two corners, we can reset the cycle and freely readjust the positioning and angle. This would mean the corners are not compound and won't affect one another (except for the entry speed, which can be slightly different). If there’s no straight and you don’t have the time to make a free adjustment, the corners are entangled and it’s crucial to get the MRP of the first corner perfect if you want to have a consistent approach in the one(s) that follows.

In compound corners, the most effective and precise way to adjust the positioning and angle of the second or third corners is to reposition the MRP of the previous one. You can do this by waiting before re-accelerating or changing direction (which changes the MRP positioning – how early or late it is), or by turning in a little later into the first corner (which changes the MRP angle – how much to the inside of the first exit the MRP is pointed).



The point of acceleration greatly impacts the exit line. If on the limit, accelerating means opening up the line. In this case, the time of acceleration will also heavily impact the entry line of the second corner.

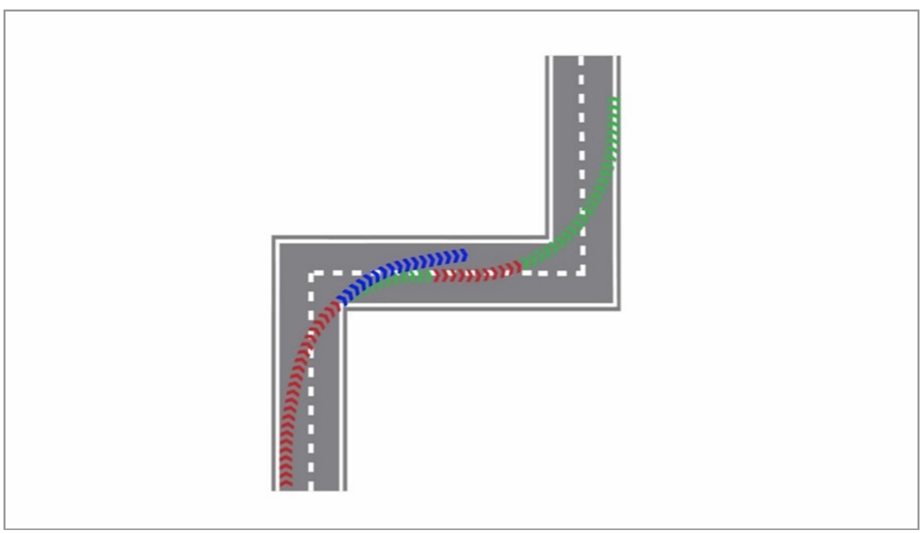
Remember that the turn-in point will affect the angle of the line. Think of the MRP as the place where you start accelerating, but don’t forget its angle –where it’s pointed. The MRP itself has a positioning and angle.



Always have the car pointed to the same place when getting back on power for better consistency. Tip: Align your car with the inside limits, like the white line or the curb, as a reference for your positioning and angle at the apex.

Compound Corners – Most Common Mistake

One of the most common mistakes in between compound corners is to force the car to open up more than it's capable of.



Line of Consequence (blue) versus attempted line

The **Line of Consequence** is what the car is capable of doing according to what you did on entry. When the car carries too much speed in the exit of the first corner and drifts wide into a bad line for the second corner, trying to force the car to open up too much for the next corner could make it even worse, and most importantly, is dangerous.

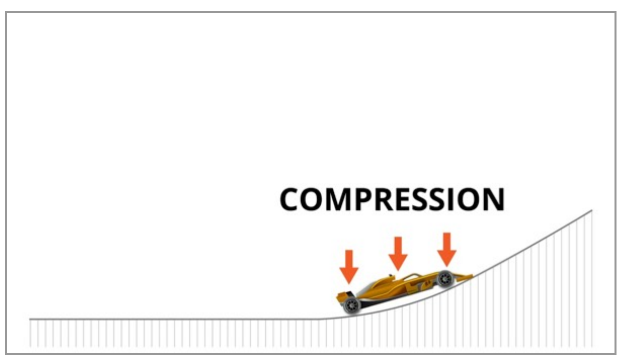
Forcing the car over its limit in between compound corners is one of the most tempting mistakes in motorsport. The solution is simple: remember that the second corner depends on what you did in the first one. Doing the same line in corner 1 and expecting the car to behave differently, or somehow gain more grip in the second one, is a waste of your time. Adjusting the MRP on corner 1 is the most efficient solution, but that can only be done on the next lap. In long sections with several compound corners, there is a snowball effect. Corner 1 will affect corner 2, which will then affect corner 3, etc. If you are on the limit, missing the first techniques in a sector like that will have a much bigger effect than missing just the last corner. Think of these long sectors as one big entity and be ultra-focused on understanding how connected these corners are.

15

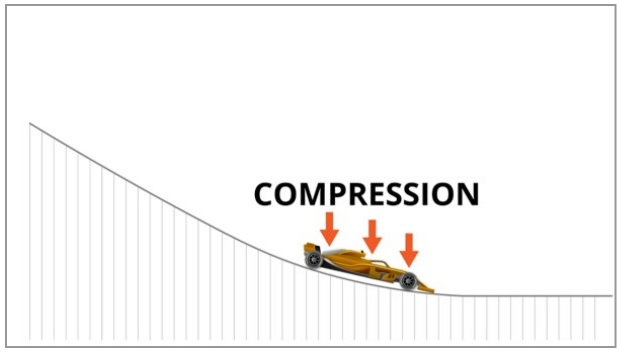
ELEVATION AND CAMBER CHANGES

Elevation and camber changes directly alter the amount of mechanical grip available. They are commonly ignored and some of the trickiest corners can be solved when we start paying attention to them. Let's start with their definitions and what to do when we encounter them on track.

Compressions



Compressions are elevation changes that increase the amount of available grip. They happen when we start going upwards from a flat track, or when we start to go flat coming from a downhill. The car will feel heavier on these types of transitions since we're essentially crashing downwards against the track, increasing tire contact and traction.



While compressed, we can ask for more from the car: to turn more, accelerate more, and brake more. Compressions generally happen over a very small amount of time, often much less than a second, so the grip available will change quickly. We already explored compressions under braking in the book, but this chapter will discuss the effects of compression on cornering situations as well.

A famous example of compression is the braking zone into the first turn at Circuit of the Americas. There, we have a huge compression where we can brake as much as 20% harder without locking the tires. Another example is the braking zone into the chicane at Road Atlanta. Right before the corner we’re going downhill, but at the braking zone the track flattens, creating a compression that allows us to brake much harder.

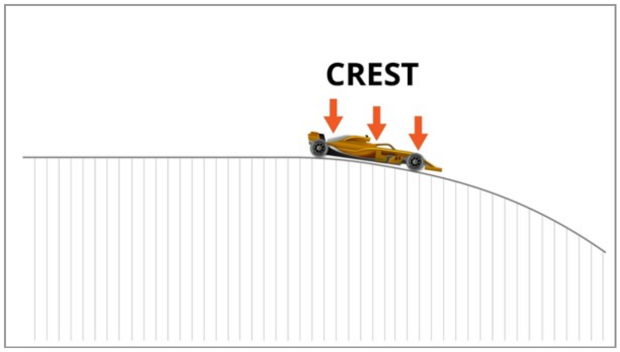
Road Atlanta, braking zone before Turns 10A and 10B

Road Atlanta also has a compression at the first corner, where the track goes upwards towards the apex, creating a compression that increases the amount the car is able to rotate due to the extra grip.

Road Atlanta, Turn 1

Crests (Decompressions)

Crests (or decompressions) are the opposite of compressions. This happens when the track starts going downhill and falling away from the car, making it feel lighter and decreasing contact between the tires and the track. On a crest there is less mechanical grip available, and we should be more patient. We will need to turn less, accelerate less, and brake less.

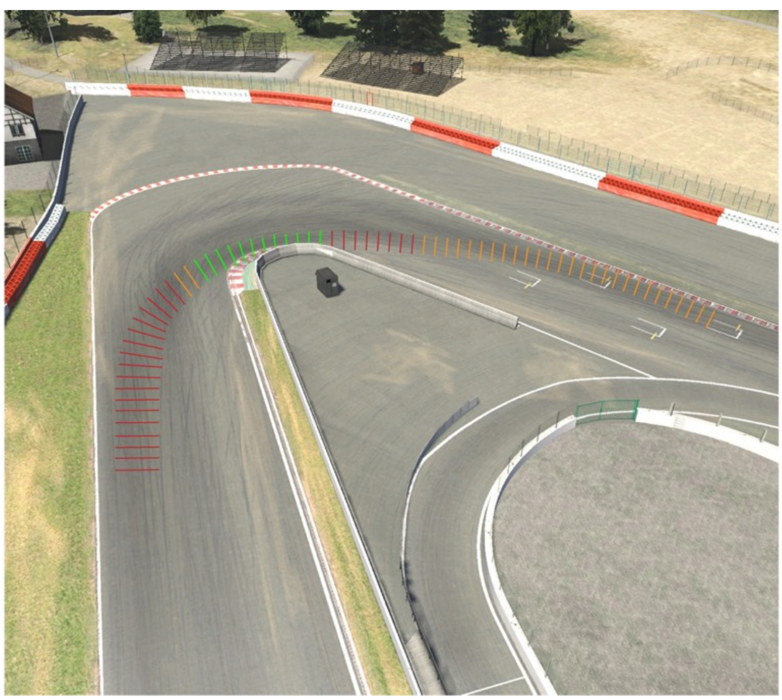


A famous example is the exit of turn one at Red Bull Ring, where the track falls at the exit, drastically decreasing the amount of available grip and causing exit oversteer. Note how the exit isn't immediately visible since the track falls away. This is a big reason drivers lose control of their cars at the exit.

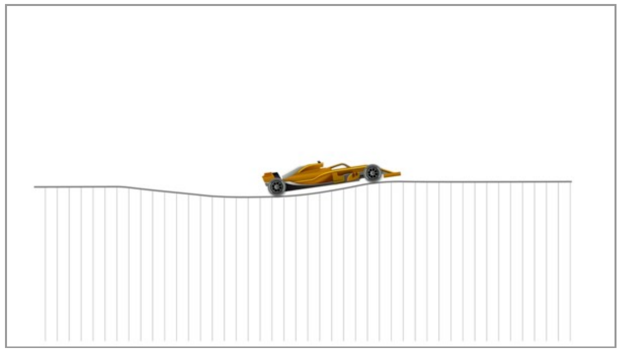
Red Bull Ring, Turn 1

Another example is the braking zone into the corkscrew at Laguna Seca. In this zone the track starts falling after we start braking, causing loss of braking performance and forcing us to release the brakes on top of the crest, coming back on the pressure after the track flattens right before the turn.

A cornering example that contains both compressions and decompressions in the same corner is La Source at Spa-Francorchamps. The corner has a small and quick dip at the apex which ends and flattens right after towards the exit. This causes a tricky effect that we'll call **compression to snap decompression**.



Spa-Francorchamps, La Source corner. Red shows areas with less grip due to crests, while green shows compressions, where the car glues more to the track and has better rotation. The orange shows neutral or flat zones.



In this drawing, we have what initially seems to be a compression. If you look closely at the beginning and end of the dip, though, you'll realize that there will be less grip in both of those places since the track falls away from the car for a fraction of a second before the compression, as well as at the very end (compression to snap decompression).

In other words, after some types of compression, the end of the compression becomes a flat track again, which ends up causing the same effect as going over a crest, causing less grip.

We must generate more rotation in compressions and less rotation on crests. Trying to generate the same amount of rotation in these two scenarios causes unpredictability and frustration.

Oulton Park, last corner. Here, we can see the turn well until after the apex, then the track starts falling towards the exit

Oulton Park, last corner. This angle clearly shows how the track falls away after the apex. Many drivers lose the car at this spot and have no idea why

Oulton Park, last corner. In this top-down view, green lines represent a compression (more grip) followed by a crest (less grip).

In the example at Oulton Park's last corner, there is a compression towards the apex, but towards late exit the track falls on a big crest and the grip disappears. This corner often catches drivers unawares. The correct approach to this corner is to generate as much rotation as possible at late entry and point the car in a straighter line at exit. Even when you think you've rotated too much and your exit will be too straight, you feel the car wanting to lose the rear on you. Understanding the compression to crest dynamic in this corner is crucial if you want to identify subtler examples in the future.

Camber Changes

Camber changes work in a similar way to crests and compressions: on-camber means the track is tilted in the direction we're turning, increasing cornering grip, and off-camber means the track is tilted outwards, making the car fall towards the outside of the corner, drastically decreasing cornering grip.

Oulton Park, Shell Oils corner. The banking (on-camber) increases mechanical grip.

Mount Panorama (Bathurst), Turn 3. Green represents more cornering grip; red represents less cornering grip.

In the example above at Bathurst, the road has a crown shape for better rain drainage. Because of that, in a right-hander, driving on the inside will give you much more cornering grip due to the camber. Conversely, driving on the outside will give you terrible cornering grip due to the off-camber. Regardless, you still need to drive the racing line. Knowing when you'll cross from the outside to the inside will be crucial to nail this corner, since the grip suddenly changes when crossing the center of the road, which is the top of the crown.

How do I Deal with Changes in Grip?

The most common mistake regarding elevation and camber changes is to just ignore them. The amount the grip changes isn't something you can ignore in these situations. Expecting the car to behave how it would on a flat straight is what causes most of the spins in crests.

Here are some tips that may appear obvious, but that are very useful:

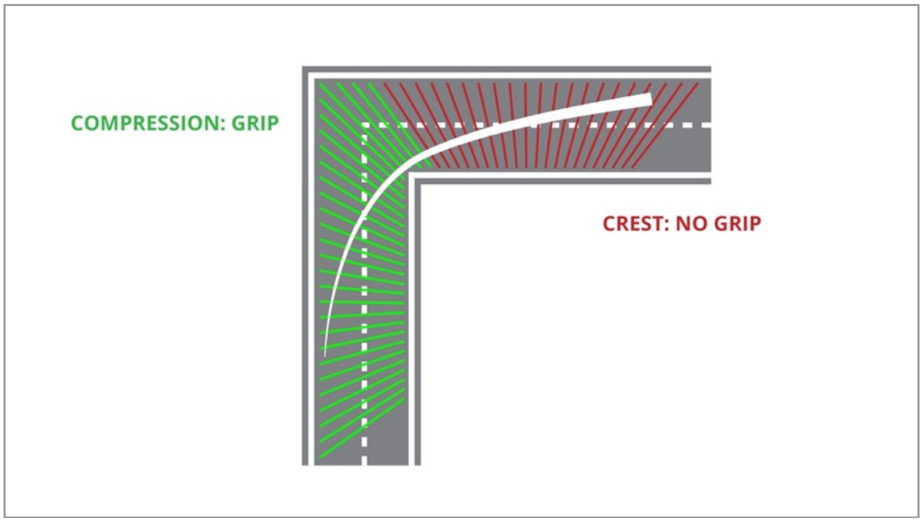
1. If you can’t see a lot of the track ahead, you are going over a crest and you’ll have much less grip on top of it.

> Road Atlanta, Turn 1. Note how when sitting close to the track, you can’t see much past corner entry. That is a clear sign that the track falls away and there will be less mechanical grip.

1. If you can see far on the track, it’s most likely a compression and there will be more grip available.

Road Atlanta, Turn 1. After the crest we identified on corner entry, we can see the track going up when it gets closer to mid-corner. That is a clear sign of a compression and that there will be more mechanical grip available. The grip available on corner entry is drastically lower compared to mid-corner.

When driving, the secret to nailing these elevation changes is to concentrate grip and rotation on compressions and banked (on-camber) corners, since we'll have the extra grip there, and to plan to drive straighter or brake less on crests and off-camber corners, since there is less grip, and the car wouldn't be able to rotate the same way. One of the most frustrating experiences in driving is being unaware of these places, always losing the car while driving through them and having no clue why. This kind of unpredictability destroys your confidence as a racing driver since you are over-driving the car while thinking you are under-driving it.



In a corner where there's a crest on exit, for example, the fastest approach is to rotate more on entry (increase the density of rotation on entry) so that the car finds itself with most of the rotation already complete before the crest, then going straighter on the crest with the car already pointing correctly to the exit. Trying to force too much rotation on top of the crest is frustrating and will never work efficiently.

In the end, when getting used to these elevation changes, you'll be constantly adjusting how to extract the most from the car. Start with the obvious ones. This will help you to slowly start noticing more subtle examples in corners and tracks where you had never thought about elevation changes before. If you think of Silverstone, for example, it really looks like there's not a lot to worry about in terms of elevation changes, but when you develop an eye for them, you'll see that some corners have a touch of off-camber, and others have a touch of a crest. Then, the grip change will be noticeable.

If you can feel subtle changes in elevation, you will easily gain many tenths per lap, as well as manage your tires more easily and make less over-driving mistakes.

MODULE III

CAR HANDLING

1

ON THE LIMIT OF YOUR LEARNING TIME

The essence of racecar driving lies in reaching the limit of traction, mostly laterally. A good racing driver carries more speed while cornering. It's definitely not about pressing the throttle harder on a straight line.

Think about driving a car in the city. The skills needed to be a good driver are in a different category: you need awareness of the pedestrians, to know the traffic rules, to adjust to other vehicles and bicycles, and to find the best routes without traffic. Losing control — hearing your tires screech — is a very rare situation in the city. In other words, in terms of traction usage, you are almost always under the limit. This means that if you never leave the city, it's possible that you spend your entire life driving around without having to know what understeer and oversteer are, unless you often drive in snowy places or off-road.

Just as driving your entire life in the city does not mean you'll go fast on the racetrack right away, being a racecar driver does not mean you'll magically understand the traffic rules of different cities in the world. The skills and preparation needed are different.

Now let's move on to the racetrack. On the very first day of practice, you might already experience traction limit. You start carrying more and more speed until you start sliding. This is where you get into a totally different skillset than city driving. Now you need to master getting to that limit in a controlled way, and stay there, while doing the fastest lines on the track.

As a racecar driver, a great number of necessary skills lie on the limit of traction. Time spent on the limit of at least one end of the car (either understeer or oversteer) is already productive in terms of learning. Of course, you want to learn both, so only understeering all the time will eventually stop being productive. Time spent understeering will make you understand one set of skills; time spent oversteering will make you learn a different set. You should balance your time driving different cars, some "understeery," others "oversteery," to develop a diverse array of abilities.

On the racetrack, if you push the car to the point of reaching the limit more often, you end up spending more time in that realm of learning. Of course, this is an extreme simplification, but I've seen it work. Making more mistakes means learning more. In my experience with coaching and racing, young drivers who are aggressive develop a better racecraft over the years. These drivers tend to use their time more efficiently, always being outside their comfort zone and polishing their skills. Simply put, if you don't push the limits of the car, you won't push the limits of your skills and they won't expand. Time spent understeering or oversteering is learning time. Time spent being too careful is wasted. Of course, in real life motorsports the approach must be much more gradual, as you look to feather the limits progressively to not crash, but you still need to be on that limit for as long as possible.

This is the reason you might hear that racing drivers from snowy countries are generally very talented. In winter, drivers must learn understeer and oversteer and spend much more time with the car sliding around, even at low speeds. This makes them naturally develop car handling skills over the limit of lateral traction. There are likely many non-racing drivers from snowy countries that understand car handling much better than racing drivers who are always under the limit.

In real life, the biggest reason for driving under the limit is fear. I've been there. Fear prevents learning. To build up confidence and learn safely, focus on the lower speed corners. These are the best and safest opportunities to throw the car around and feel its dynamics when on the limit. As you gain confidence and understand the car's behavior, move on to being more aggressive on medium-speed corners, before finally tackling the high-speed ones.

We can then push this concept to the highest level, starting to divide the corner into smaller pieces: entry and exit, then early entry, late entry, early exit, and late exit. You can then ask yourself if you are on the traction limit in all the stages. Not being on the limit and not noticing it is useless for technique development. You must be either understeering or oversteering (or a little bit of both; think of a go-kart with a high slip angle going slightly sideways with all four tires sliding equally) at all stages of the corner.

Imagine that you are doing a low-speed corner, and you turn in at the ideal line, without sliding, and when you get back on power at the apex, you start oversteering a little bit on exit. In this situation (being slightly slower than ideal and doing the line perfectly) it is easy to miss that we're under the limit, especially on entry. In this example, the corner probably felt okay, but we missed learning time on entry. The most efficient practice sessions will be the ones where you spend more time on the limit of your tires. Think about this limit mostly as rotation. You can judge how much the car *is* rotating versus how much it *can* rotate at that speed. If it can rotate more than you expected, you were under the limit and you can carry more speed on the next lap.

The simplest way to group handling adjustments and judge the traction limit is rotation x speed. If you are not on the limit of rotation, carry more speed. If the car refuses to rotate and either understeers or oversteers and slides out, carry less speed.

2

DRIVING THE LINE VS DRIVING THE CAR

Imagine two different drivers. One focuses on keeping the car on the ideal line as much as possible. They use every inch of the track, on entry, apex, and exit. The second driver focuses on feeling the grip limit of the tires, rotating the car as much as possible, even if that means not using the whole track on exit, for example.

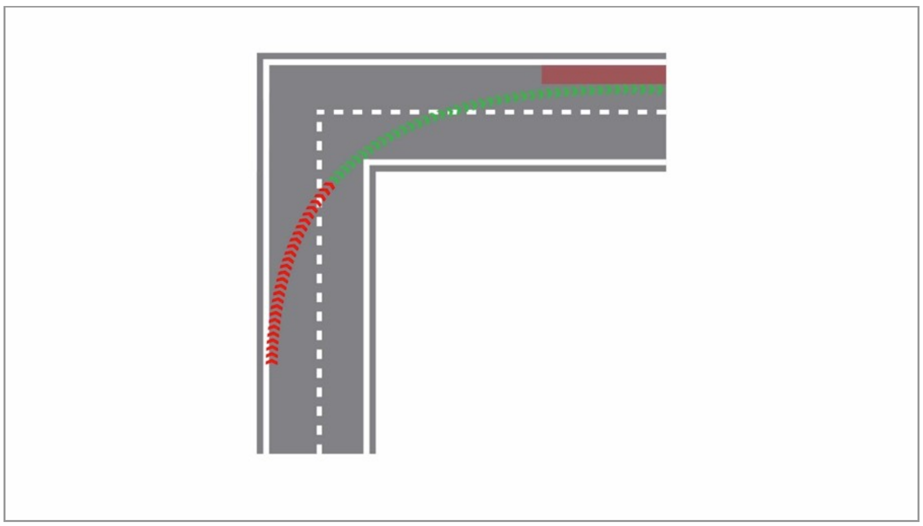
These are two extremes. Most drivers have a little bit of both mentalities when driving a racecar. We just need to find the right balance between them.

Driving the Line is the most comfortable driving approach. You can be slightly under the limit and do the perfect line all day. This can be a safe mentality if you are taking care of the tires in an endurance race, for example. Here's the problem with it: it invites you to stay in your comfort zone. It might even trick you into thinking that you are on the limit and that you are carrying the right amount of speed into a corner.

Driving the Car is trying to always reach the cornering grip limit. It's reaching out to that point where you know the car is on the verge of sliding too much. It's asking for as much as the car can offer. This approach will make the car rotate a specific amount depending on the speed, until it understeers or oversteers. If the car is too slow for that corner, it will do a tighter line than necessary, and two things will happen.

First, if you are on corner entry, the car will just point more than necessary towards the apex, and you'll need to adjust the steering. When this happens, you'll quickly realize that the car has more grip to offer, and you can carry a little more speed on the next lap. When you correct the steering to come back to the line after being too far on the inside, you won't use the grip on the front tires, which clearly shows you are under the limit. (Bouncing off the apex, remember?)

Second, if you are on corner exit, you'll turn more than necessary on exit and not use the whole track. This is the most effective way to feel that you can carry more speed through a corner.



> IMPORTANT: Artificially using the whole track on exit by unwinding the steering can easily hide the fact that you are not using all the grip that is available. You might think that you are on the limit because you are driving the right line, but if all four tires are not on the limit the whole time, and you can't do a tighter line, you are not carrying enough speed on exit. The right exit speed gives you only one choice: use the whole track on exit.

On the simulator, "driving the car" is the most effective approach as you can overshoot the corner a lot, and even spin or crash, without any consequences. In real life, you have to balance the two approaches. Try to stay close to the racing line (driving the line) while making some micro-tests for grip (driving the car), without making big changes in entry speed.

Remember that adjustments in speed on corner entry should be based solely on braking. If you want to carry more speed into a corner, brake less. Braking hard and then accelerating earlier while still on corner entry will upset the car on exit and is not the most efficient way to do the corner.

Adjustments in speed on corner exit will depend on your line and speed on entry, but you can always try to accelerate a little earlier and test the placement of your Maximum Rotation Point.

If you can increase the overall speed of the car without affecting line and rotation, you are gaining time. It’s as simple as that. But if you can increase rotation without affecting speed, this means you can carry more speed on the next lap. This approach is the most efficient when learning a new car/track combo.

3

WHAT IS OVERDRIVING THE CAR, REALLY?

Traditionally, to overdrive the car is to try to do a corner at a higher speed than the car is capable of and getting too much understeer or oversteer, missing the line of the corner, and having to back off or wait too much before getting back on power.

Overdriving is a common, even necessary, part of looking for better lap times. But there's more than one way of doing it.

Speed First, Rotation After

Braking too late is the most common way to overdrive. Here, you find speed by braking later and later, and then trying to deal with the extra speed mid-corner. This approach shifts our focus towards the braking reference: you brake at 100m, then you try to do the corner. Then you brake at 90m and try again. Then 80m, 70m, etc. until you can't make the apex anymore or you can't rotate the car, meaning you have to wait and get back on power after the apex, which is slow. After you miss the apex, you back off to 80m to try again on the next lap.

Again, this process shifts our focus towards the braking reference, which means we're not focusing as much on the following phases, especially if we're desperately trying to stay on track.

Let's call this the **speed to rotation** approach. This means we prioritize the entry speed more than anything, and then we just "deal with it" mid-corner.

The speed to rotation approach is not enough. Only doing this can mean that you develop your car handling skills in an extremely subconscious manner, which can be bad if you are also developing bad habits.

Rotation First, Speed After

There's a smarter way to test the grip limits of a racecar. That does not mean it is the only way and that you should ignore everything else. It's just one more tool for you to use in your technique development.

You'll note that the remainder of the book will be hyper focused on rotation. How to feel it, how to control it, how to cause mistakes on purpose so you can prevent them – it's all about lateral grip. While I say that 90% of motorsports is braking, a big part of braking is pointing the car into the corner, too. The way you carry the brakes into the corner can impact how much the car oversteers or understeers. Ignorant of this, you'll still blame the setup.

Aim to reach the rotation limits on corner entry *before* you build up the braking references. You'll do this by starting at a slightly lower speed. Why? Because you'll have the mental space to pay attention to the lateral grip, to the rotation, and to your inputs into the corner. Test the rotation of the car by deliberately inducing a little bit of understeer, and then minimize that and test pointing the car more aggressively, feeling a little bit of oversteer. The information you get from this is more important than anything else. With it, you can have a much more precise idea of how much extra speed you can carry through that corner. After all that, you can adjust the braking reference accordingly.

Let's call this the **rotation to speed** approach. This means we prioritize the rotational capability and control of the car more than anything, and then we adjust the entry speed afterwards.

The rotation to speed approach is the one I use in real life to maximize my testing efficiency and my track time. I can safely test the rotational limit of the car and oversteer a little while being at a safe speed. This gives me enough information to set my braking references quickly.

4

CHANGE THE DRIVING OR CHANGE THE SETUP?

Let me tell you a story. A driver approached me looking for high level coaching with a focus on setup changes. We started the session driving the Porsche 911 Cup car at Brands Hatch in iRacing. To warm up, we both went on track and did some laps. After around 10 minutes of lapping, I did a 1.24.9 and he did a 1.26.1, with the same baseline setup. At this point, I already felt that the session couldn't focus only on setup – especially because you can't just talk about setup if you are obsessed with driving technique like I am. Also, I knew there was a good point to be made about the relation between driving changes and setup changes.

I then asked him how he felt about the car. He said it wouldn't turn, that it was understeery. I agreed with him; it was indeed. But the car was still drivable and with the right driving style we could get a nice neutral steer towards oversteer on exit (where all four tires were working, and the car was sliding just right). So, the car understeered on entry and oversteered on exit.

Before making any changes to the setup, I figured it would be a lot more productive to try to minimize the time differences between his lap time and my lap time.

Here's the catch: instead of making a setup change to make the car rotate more, I instructed him to induce more rotation using driving technique. After looking at the replays and telemetry, we identified that he was turning in too fast, something he would do naturally because of his experience with karts in real life and Formula 3 cars in iRacing. Light and high downforce cars accept (and sometimes even require) this quicker initial turn-in to reach maximum usage of the four tires right away, but heavy and low downforce cars are not forgiven by inertia and the front tires need some time to start moving all that weight around. We'll talk about exponential steering versus linear steering later in this book.

After finding more grip in the front tires through a driving style that was better suited to that car, he found 8 tenths of a second in his lap time, decreasing his time from a 26.1 to a 25.3. No setup change was done. Then, it was time to change the setup and give the car the front grip we felt we needed at the beginning of the coaching session.

We decreased the anti-roll bar stiffness on the front of the car, and we went back on track. The car immediately turned much more easily on corner entry. His reaction was positive, feeling that the car was so much more responsive on entry. Using the technique we worked on before, he was able to make the car turn as much as he wanted on entry, even oversteer, which is quite rare in this car under braking because of its nature. However, his lap times did not improve.

The problem was that this extra rotation on entry was overheating the rear tires and then the car had less traction overall at the very end of the corner, which made it slower. He did not improve his 25.3 with the setup that "felt better." Because the understeery setup was still drivable, he went back to the original setup and was doing a great job inducing more rotation. The car was planted and rotated nicely on exit with aggressive throttle application while keeping good traction.

This is where the most important lesson of our session emerged. Only make changes to the setup that will make the car faster. A setup that feels better won't necessarily do faster lap times, because the overall balance of the car (in terms of rotation) does not guarantee that you'll carry more speed through the corner. It is incredibly important to look at data and have a lap time delta when trying new setup changes to make sure that it not only feels better, but actually gains you time.

Keep in mind that we are focusing on hot lapping and finding lap time in this example. In other situations, like preparing the car for a long endurance event, it might make sense to change the setup to make it feel better, be more predictable, and be less prone to mistakes, like if you are going to be on track for long hours.

The second important point of the lesson was that you don't necessarily have to make setup changes to change how much the car rotates. Driving adjustments might have an even bigger impact on the way the car behaves. A skilled racecar driver should be able to make an understeery car rotate more, even oversteer, or an oversteery car rotate less, even understeer, with the right braking, downshifting, brake release, steering, and throttle application.

Try your best to make the car behave how you want it to by making driving adjustments before making changes to the setup. Prioritizing driving adjustments will save you a lot of time and will help you improve your driving technique much more efficiently.

5

FEELING UNDERSTEER AND OVERSTEER

What is Oversteer and Understeer?

I know there is a lot of confusion even amongst high level drivers regarding oversteer and understeer. Their names suggest that understeer means you are just turning the steering less, and that oversteer means that you are turning the steering too much. This is incorrect. As a matter of fact, understeer generally happens when you are turning the steering *too much*.

The best way to understand these concepts is by replacing "understeer” with "under-rotation” and "oversteer” with “over-rotation.”

Understeer means the car does not want to turn as much as your steering input would suggest, meaning you end up going straighter than you expected. For example, your steering might be asking to turn 50 degrees per second, but the car is only turning 25 degrees per second. Understeer happens when the front tires *try* to point the car into a corner, but the rears are resisting that rotation. The front tires then give up, and the car starts pushing forwards against the intended steering angle.

Oversteer means the car rotates *more* than you expected. For example, your steering might be asking to turn 50 degrees per second, but the car rotates more than that, turning 70 degrees per second. Oversteer happens when the front tires point the car into the corner, but the rears are not capable of that much traction, and they give up. The rear then starts sliding, moving outwards more than the front end of the car, which makes the total slip angle of the car way over the acceptable limit. It's important to note here that oversteer is always a reaction, as the front tires need to initiate the rotation before the rears start to give up. Remember this.

Feeling Understeer

Understeer is the safest way around the track, when at the right speed. But it can be quite dangerous if you are too fast since it'll throw you off track. The front tires reach their limit first and become incapable of generating a higher amount of rotation. In understeer, we are on the limit of only two tires, with the rear tires taking little stress. Through understeer, the car locks itself into a path (when controlled and done consciously) and pushes forward like it's on rails. Because of this, we can predict the path of the car a lot easier, and we can then "go along for the ride" to understand the rotational capability of the car at that point and speed on track.

This is remarkably useful. Feeling that understeer will give you an idea of how much speed the car can carry in that corner, since the speeds on a neutral or oversteery car won't be much higher than that. In other words, if you understeer through a corner, you will have a good idea of how much speed the car will carry when doing a full send. For beginners, understeer tends to be easier to deal with, especially during a long stint. The car gets into a predictable line, and you go along for the ride. As long as your speed is close to ideal, you can mostly wait for the car to turn until you feel comfortable to accelerate. You can spend a long amount of time, sometimes full seconds, doing nothing, just waiting for the car to turn. So, we can say that understeer is the easiest way to put you in a nice comfort zone as you are cruising around the corner.

Feeling Oversteer

Oversteer happens when the front tires have done too great of a job – so much so that the rears could not keep up with such a demand for rotation. At this point, the car becomes unstable, and things happen fast. racecars are not made for drifting. When they oversteer, they can go over the point of no return very quickly and spin. Then, a reaction is required to prevent spin.

Oversteer is always a result of something. Understeer happens when the fronts fail to rotate the car – it can happen immediately if we flick the steering, for example. But oversteer always happens as a consequence of the front tires initiating a rotation that the rears won't be able to cope with. Because of this, oversteer happens because of excessive grip on the front tires. The exception would be when locking up the rears, which drastically decreases the available grip.

Oversteer may be a bit more complicated to learn at first. At the beginning, it will happen faster than you are prepared for, which might scare you or make you spin. Initially, we are not capable of feeling the car start to oversteer fast enough, and we end up not making a correction in time, which makes it even worse. But as we start predicting what kinds of inputs cause more oversteer (like trail braking, engine braking, and steering), we become more prepared to deal with it and make it happen in smaller and smaller amounts. When we correct oversteer with countersteer, we end up stopping the front tires from creating forces towards the inside of the corner, so during the correction of a big oversteer we're only using two tires, just like understeer. Remember when I said oversteer is a reaction? It reacts to the driver giving too much grip to the front tires. So, we do have some amount of control over how much oversteer we cause, especially if we're aware of an oversteery setup or car.

Neutral Steer

Based on what we have learned about oversteer and understeer, you don't want to be doing either of them, right? Then why does everyone keep saying they want a car that oversteers more or that understeers more? If both are bad, what should we aim for? None? Both? It is actually possible, and preferable, to have both ends of the car on the limit (and beyond) at the same time. This is called **neutral steer**.

Neutral steer means that the car has the *same* amount of slip angle ("scrub") on both the front and rear tires. Of course, it is impossible to be at this state during the entirety of a corner. You will have to turn the steering to initiate a corner, change direction, or make adjustments, so you'll be in and out of this state, making corrections to try to keep the car in a neutral state for the longest time possible.

Neutral steer is the ultimate goal of car handling. This is where you'll extract the maximum grip possible from all four tires. Removing the driving line from the equation, the faster driver will be the one who spends the most time in this state.

Neutral steer happens when we get used to both understeer and oversteer to the point where we start dealing with microscopic aspects of them, and we start “dancing with the car.” This is when we start spending more and more time in a state where the car is indeed sliding both ends a little bit. A clear case of neutral steer is when the car is drifting through a corner, but the steering is completely neutral. This does *not* mean that we should spend the most time possible with the steering pointing straight! We can still reach the neutral steer state (front and rear tires sliding a bit) with some steering angle. The lower the speed, the more steering we want.

To summarize, in understeer we are using two tires at the limit, in oversteer we’re using two tires at the limit, and in neutral steer we’re using all four tires on the limit.

With the magical ideal neutral steer in mind, we can still ask ourselves if it is faster to drive an oversteery car versus an understeery car.

Bear in mind that you can still induce understeer in oversteery setups, and induce oversteer (to some extent) in understeery setups. But the first case is definitely easier! That's why the vast majority of the fastest drivers will prefer an oversteery car.

Do I Choose a Car that Oversteers or Understeers?

An oversteery car allows you to spend much more time in the neutral steer state, as you have some room for correction. It is much more difficult to get away from just destroying the front tires in an understeery car.

Oversteer is a more controllable state which forces you to drive more actively, with many small corrections, which makes you more present and focused. An understeery car is lazy. Sometimes there's nothing you can do about it, because to correct the understeer you end up over slowing the car way too much, making you lose seconds of your lap time.

Some cars look like they don't oversteer at all, especially racecars with slick tires. Why is this? It is because of something called **slip angle**. The optimal slip angle is how much a tire should be sliding to give the maximum traction possible.

Some tires have a much higher slip angle, like road tires, and driving them on the limit makes it look like the car is sliding all the time. The lesser the slip angle, the less it looks like the car is going sideways. This is why karts and historic cars seem to always be sliding while Formula 1 cars look like they're on rails, not sliding at all. But they are!

Rear-wheel drive cars are capable of maintaining neutral steer for the entirety of the corner. This is not the case for front-wheel drive cars, since accelerating out of the corner with torque being added on the front tires decreases rotation drastically, generally causing understeer on exit.

If you are too used to understeery cars and want to find those last seconds in your lap time, get out of your comfort zone and think about this. If you are dealing with fixed setups and the cars understeer or oversteer way too much, you have to start inducing the opposite behavior through driving inputs. Inducing understeer and inducing oversteer are two crucial techniques to reach the neutral state in different cars.

6

WHAT IS TRAIL BRAKING?

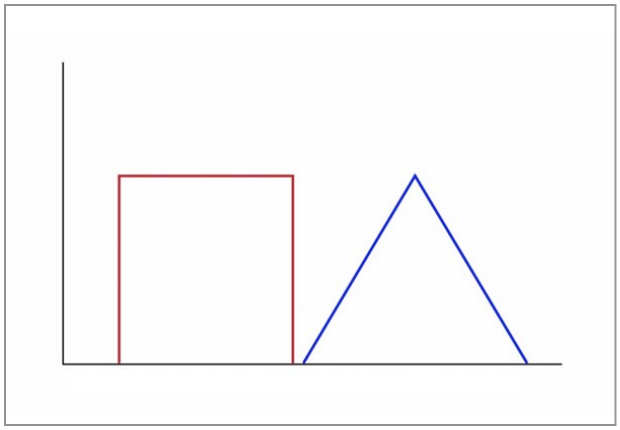
The brakes have two functions in racecars, one of which is widely underestimated. The first and most important one is deceleration. It is the one we all know since it is the only one in urban cars. In racecars, we use the brakes not only to decelerate, but also to rotate the car. But we should not individually brake on a straight line, then release the brakes, then start turning, and then use the brakes to turn the car more. This would create a gap on the grip usage levels of the tires. We should blend these two functions, braking and rotation, together while keeping the car on the limit of traction. **Trail braking** is the technical term for blending these two functions in the most effective way. In the next chapters, we will learn ways to build up and perfect this technique to the highest level.

7

THE STRING THEORY

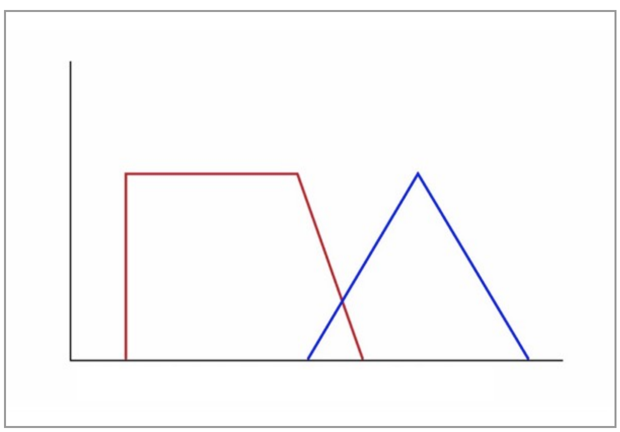
As beginners, we learn that we should not brake and turn at the same time while at the maximum capacity of either. If we try to do both at the same time anyway, we will exceed the grip limit of the tires and lose control of the car in some way. The simplest way to learn this distinction is to completely separate the inputs by finishing the braking before we start turning the car. Although this is the safest way to learn, we then leave a gap in between the two inputs, consequently being under the limit of grip for that moment. This gap becomes smaller and smaller as we progress towards high performance driving.

In this first graph, we are using 100% of the grip available under braking, and as we drop the brakes to zero while still in a straight line, we bring the grip usage down to 0% until we start turning. When we do that, we're wasting precious seconds that could have been used to slow or turn the car, making us spend more time in that corner than necessary. This step is necessary for beginners, though. Not only do we need to mentally understand these two inputs individually, but we also need to teach our body how to control them. We learn in big chunks first. At this point, we can feel the difference between full brakes and no brakes, or steering a lot and not steering at all, but the subtleties in between (smaller chunks) will be perceivable as we develop muscular (and mental) sensitivity.



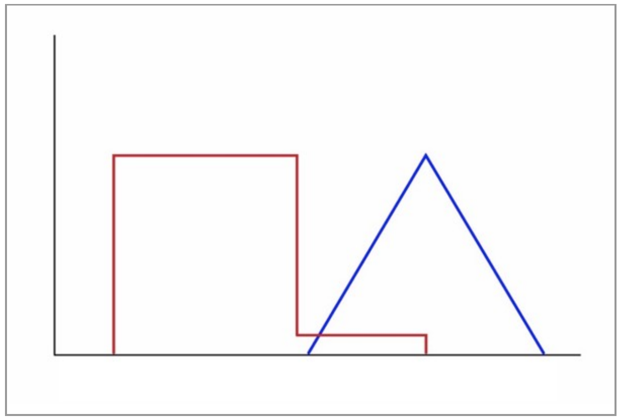
Beginners' braking (red) versus steering telemetry traces (blue)

As we progress, we either learn that we need to release the brakes more slowly to maintain a little bit of weight on the front tires, or continue to brake lightly while turning, for the same reason, or both. These two ideas can work together, although most drivers won't perfect this right away, since trying both at the same time generally causes the car to over slow, which feels wrong and makes us stop braking more quickly at one of the stages.



Beginners' braking (red) versus steering (blue) telemetry traces, with slower release of the brakes, increasing turn-in rotation.

In the graph above, we still have some brake pressure applied while turning in, which makes the car rotate more on entry, but as we reach 0% braking (coasting), the car starts understeering deep into the corner (mid-corner).



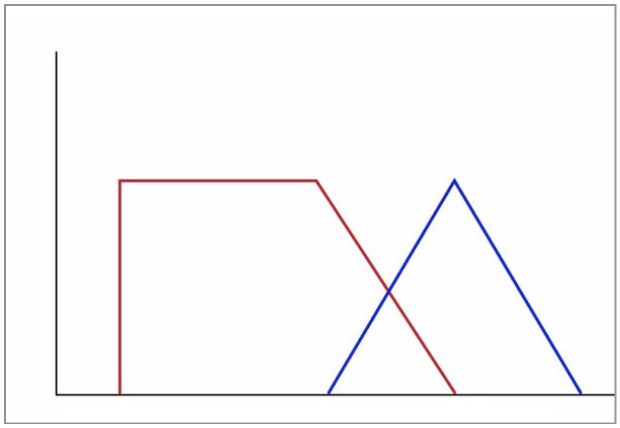
> Trail braking with constant feathering while turning, which allows more rotation.

In this third example, the quick drop in the brakes causes the car to turn in less aggressively (understeer on entry), but the feathering of the brakes until mid-corner (where we start accelerating) causes a little more overall rotation.

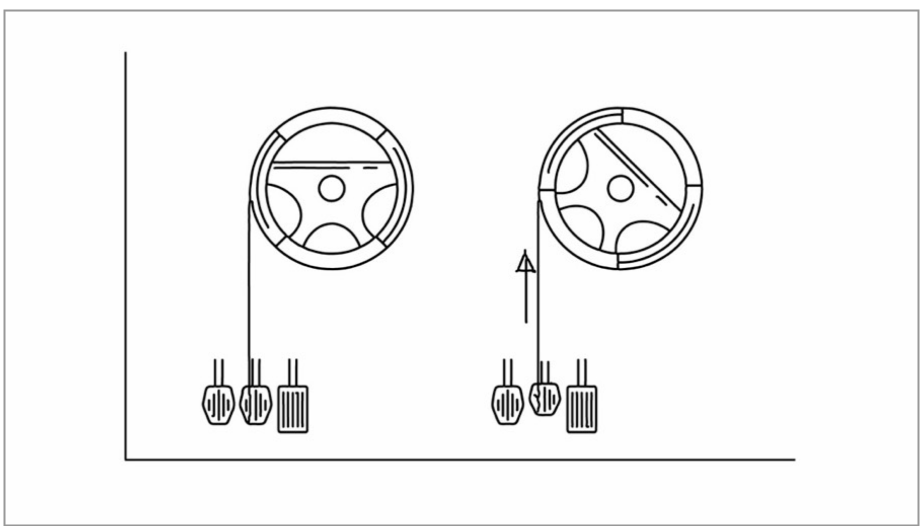
To optimize the grip of the racecar, we need to efficiently transition the energy used to stop the car into energy used to turn the car, as if we were pouring liquid from one cup to another, while maintaining 100% grip usage, or without spilling a drop of liquid.

For example:

100% braking = 0% turning
90% braking = 10% turning
50% braking = 50% turning
T% braking = 100% turning



The string theory is a way to visualize the entanglement between these two inputs. The string theory relates the brake release to the steering input, as if there was an imaginary string between the side of steering and the brake pedal. This way, when you turn, you feel this imaginary connection pulling the brakes upwards accordingly. I say "accordingly" because it should really follow the speed of turning. Turn in slowly, release the brakes slowly. Turn in quickly, release the brakes quickly.

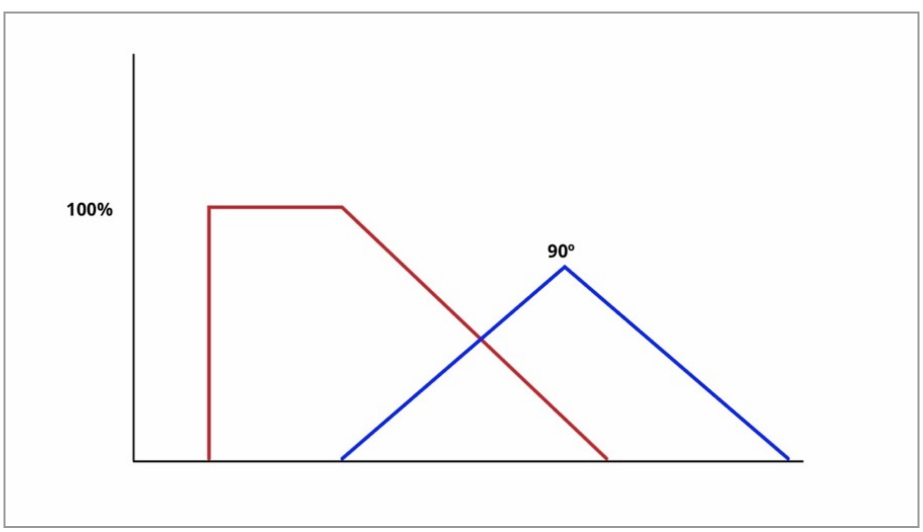


By thinking of the relation between steering and braking like this we can create a trigger in our brain, and after enough practice, we will automatically release the brakes as we increase steering, through muscle memory, without even thinking about it. It is a mistake to add steering while maintaining the brakes at the same pressure. The inverse is also true. While coming from a corner into another braking zone (think about Acqua Minerale, at Imola) we should never increase the brakes while maintaining the steering, as that immediately upsets the car into locking the fronts or spinning, depending on car and setup. The immediacy of response from the car when you start to apply the string theory is incredible.

Note that this is an extremely simplistic visualization of a much more complex technique, although it is a foundational technique that will enable us to master others. I will discuss the idea of the string theory in more depth to give you a better idea about the types of adjustments that can be done to it.

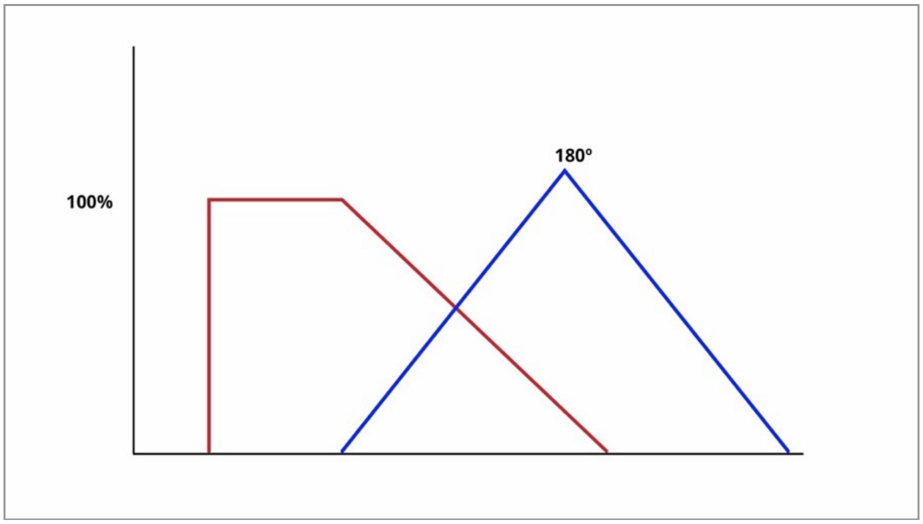
Ratios of String Theory

First, let's discuss the different ratios of the string theory. The ratio in this instance is the correlation between how much we turn versus how much we release the brakes. Try all these examples in your car or simulator, with the car stopped. It's impossible to determine "the correct" ratio between the steering angle and braking pressure immediately, since it will heavily depend on many factors. Instead, for these exercises we will assume and practice different ratios to create a range of possibilities in our muscle memory.



Example One: 100% brakes and 0 degrees of steering angle
T% brakes and 90 degrees steering angle.

In this example, for each percentage of brake release, we turn a little less than 1 degree of steering angle.



Example Two: 100% brakes and 0 degrees of steering angle
T% and 180 degrees steering angle.

In this example, for each percentage of brake release, we turn two times more than what we were turning in the first example. This means we're turning the steering faster but releasing the brakes at the same speed.

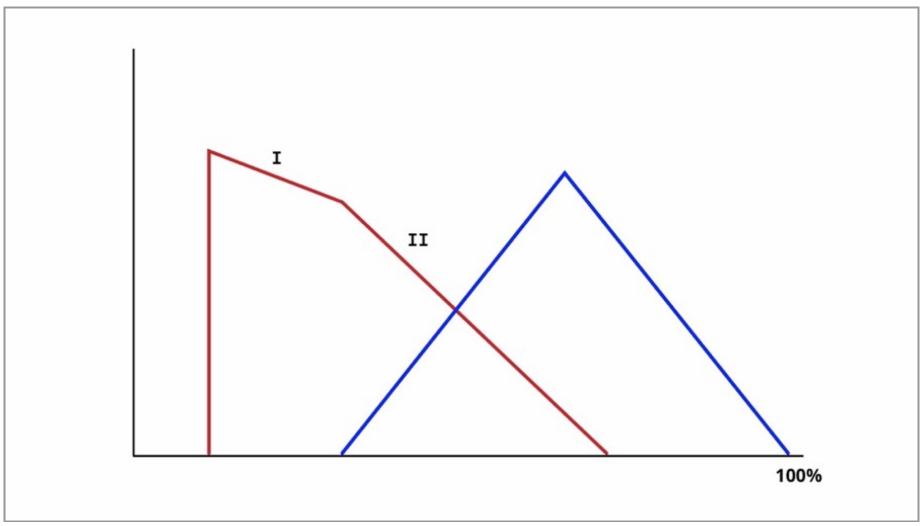
Don't over-think these values too much. They're just examples to show you that we can have infinite types of "strings." The benefit of this exercise is creating the connection between the inputs in your brain since we'll use this inverse proportion in absolutely any corner, at any track, and in any car, in road racing. Try this until you can recreate these different ratios with ease and make this inverse proportion become natural in your driving.

Again, the biggest mistake to avoid is to increase steering input and brake pressure at the same time. Do this and you will most likely exceed the available grip of the car and its reaction will be unpredictable and inefficient.

The string theory is one of the most important pillars for high performance driving technique. It is the foundation for other more complex techniques that will be discussed later. These next techniques will require the muscle memory that you'll develop using the string theory. Make sure you practice this in many different situations, in all kinds of corners and cars. Later, we'll polish this theory with other considerations, and it'll feel slightly different. Allow yourself to practice the string theory and then forget about it. Your muscle memory will retain the important stuff.

String Theory in High Downforce Cars

At this point, you should be able to release the brakes very slowly using the Press Less Technique that we need under braking with high downforce cars. For these cars, you'll use the very same technique, just increasing the speed of release as you start turning in.

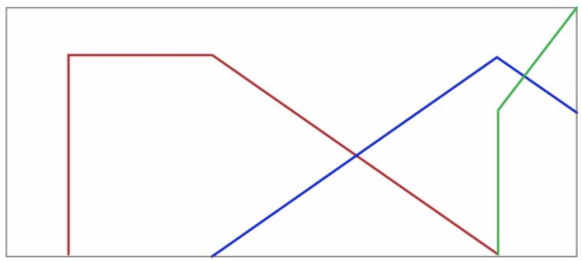


I: Brake release in a straight line due to loss of downforce. II: Brake release due to the string theory (pouring grip availability into turning).

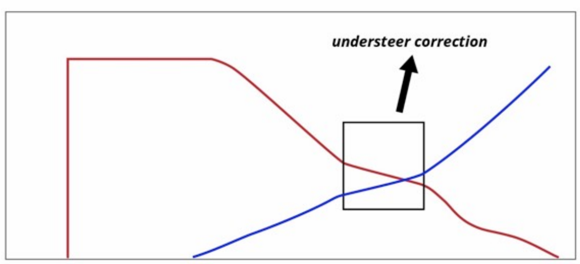
This does look more difficult to accomplish in terms of precision, but it's just a matter of time and repetition until the brain is able to separate these two stages with ease. Repetition with good awareness of these two stages is going to be the key during your practice.

Advanced String Theory

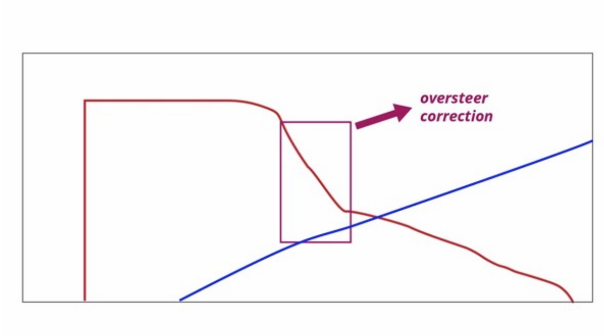
The string theory discussed in the last chapter takes some time to become part of your driving. With it, we can get more rotation into the corners and brake later. But that’s still not good enough. It’s possible to have even more precise balance control to make sure we keep the same state of neutral steer (all four tires working equally) for the most amount of time possible during a corner. By just linking the brake release to the steering, we end up creating a rather linear relation, which is not ideal.



Brake release when rotation is linear and progressive. Braking trace is in red, steering in blue, and throttle application in green.



Brake release according to the advanced string theory. When understeering, keep the brakes pressed for a little longer while increasing the steering at a lower rate to regain grip on the front tires.



Brake release according to the advanced string theory. When oversteering, release the brakes more quickly to transfer weight to the rear tires to regain the grip and control the oversteer. (Note that there is no correction in the steering in this case. We will discuss this later.)

We don't release the brakes at a completely fixed rate. We don't turn the steering at a completely fixed rate either. Other factors like downforce, elevation changes, engine braking, and camber will drastically change the driving approach into different corners.

Instead of releasing the brakes according to how much you turn the steering wheel, try releasing the brakes according to how much the car *rotates*. When we turn the car, the steering is the input and the rotation is the output. In the regular string theory, we release the brakes according to the input. In the advanced string theory, we release the brakes according to the output, or the response of the car.

The main benefits of the advanced string theory are the following:

1. More freedom. You can turn the steering at different rates without worrying too much about making those adjustments to the brake release.
2. You'll stay closer to the limit. By sensing rotation and releasing the brakes according to it, you'll carry more speed as soon as you feel the car is responding and turning into the corner.

This only works if you do it with subtlety. It doesn't look very different to the regular string theory. It's a way to feel the rotation in a way that will allow you to make micro-adjustments with the brake release without affecting the steering too much, for example. These micro-adjustments will be mostly used to correct the rotation of the car – inducing understeer and inducing oversteer. There are many ways we can describe how this works, and in the next chapters you'll see how we're just analyzing the same thing through many different perspectives.

8

TERMINAL TRAIL BRAKING PRESSURE

What was that T% mentioned in the string theory chapter?

T% is what I call terminal trail braking pressure. It is the brake pressure that we'll have by the time we start accelerating. Some cars can't handle more than 3~4% braking pressure mid-corner before accelerating or they'll start locking up the inside front. Other cars require that you keep a heavy trail braking, with a terminal trail braking pressure around 20%. If you are coasting before accelerating out of the corner, that means your terminal trail braking is 0%.

When on the limit, we are using the optimal slip angle of the tires *plus* a bit of braking in order to, in the example of the front tires, have some weight transfer and increase the grip available. That small amount of pressure is clearly demonstrated when doing that final trail braking stage mid-corner.

The terminal trail braking pressure will be affected by the amount of mechanical grip available. Trail braking on a low-grip off-camber corner must be much lighter, so the T% is lower. Trail braking on a high-grip compression or banked corner can be heavier since the car will have much more traction.

On cars with very stiff front suspension, where the front inside tire can even be lifted off the track while turning, the T% must be very low since even braking at 1% may lock up the flying tire. In these situations, bringing the brake bias towards the rear helps minimize the issue.

Ideally, you want to generate as much rotation as possible without losing the rear while trail braking into a corner. The ideal T% pressure is the one that maximizes the usage of the front tires, making the car rotate more. There will be an optimal combination of T% and brake bias (as well as setup) that will determine the rotation of the car and the speed it will carry mid-corner. Experimentation is the best way to find it, and awareness of this concept can help you make more precise and surgical adjustments in your driving.

9

THREE TOOLS FOR ROTATION ON ENTRY

When turning into the corner, there are three ways to make the car turn related to driving inputs. Car setup and brake bias are not going to be mentioned since they're adjustments that cannot be made during a corner.

The three tools every driver can adjust that will alter rotation on entry, either to increase or decrease it, are the steering, the trail braking, and the engine braking. Technically, there is a fourth tool, the maintenance throttle,[1] but it should be used rarely, and in extreme cases where the car wants to rotate way too much due to its nature (like having an open differential or a specific setup). Because of its rarity, I won't mention it right away.

Steering

The steering determines the direction of the rotation. Yes, you can make the car turn depending on the steering angle and how quickly you adjust that angle, but this characteristic is often overlooked. Turning too much in a balanced car can cause understeer, and relying only on steering angle to control the balance of the car is limited. If you only worry about the steering, buckle up and pay attention to the next two tools.

Trail Braking

Trail braking will mostly determine how much weight there will be on the front versus the rear tires, and therefore how much traction each end has. Think of it as a way to empower or lessen the rotational capability of the car. With the exact same steering angle, you can have a car that understeers terribly or that spins very quickly just by having a different trail braking trace. I have encountered hundreds of drivers who started gaining rotation in the car by turning the steering *less* and focusing on keeping the weight on the front tires by trail braking more slowly. By changing the brake bias, you change how much braking stress goes to the rears versus the fronts, which will alter how much rotation the trail braking will cause. But again, this cannot be changed during the corner, so if you get too much rotation in that fraction of a second, changing the brake bias will not be an option.

Engine Braking

Engine braking (on rear-wheel drive racecars) will act as very light brakes on the rear tires. When off throttle, the engine's inertia tries to slow down the tires a little bit. In this moment, the rear tires are keeping the engine running. That's why when you lock-up the rear tires, you can hear the engine "turning off" for a moment and starting back up when you unlock the tires.

The higher the RPM, the stronger the engine braking will be. During turn-in, the engine braking will decrease the resistance to rotation of the rear tires, allowing the car to turn a lot more. In some cars, the engine braking has a big effect on rotation: with a fixed steering trace, trail braking trace, and a change to the downshifting speed, you can have a car that completely understeers or a car that oversteers and spins.

Downshifting can have two effects on the car. The most pronounced and discussed effect is the engine braking that comes with high RPM acting as slight braking on the rear tires. But the abrupt change in RPM itself due to the engine speed on the new lower gear matching the current wheel speeds will upset the rear tires in many cars. That means downshifting after turn-in might create a bigger effect, making the car lose the rear during the fraction of a second the downshifting takes effect.

Let me give you an example. I was racing in Formula 4 in Miami and doing a corner where I could choose to downshift to second gear before turning or after turn-in at a lower speed. In this example, downshifting to second gear at a lower speed theoretically makes the car rotate less, since we would have a lower RPM deeper into the corner. But what really happened was the opposite: I would lose the rear if I downshifted *later*, while turning into the corner. The reason is that the *act* of downshifting caused stress to the rear tires, making the car slide for a fraction of a second, but that would end up snowballing into losing the car altogether. While downshifting earlier, I would get *more* engine braking, which would theoretically make the car rotate more, but in a more predictable way, so I was able to manage that extra rotational tendency with my steering angle and trail braking.

This example shows why its preferable to have the last downshift before you turn into the corner, whenever possible. Of course, there are specific situations where you would have to downshift during the corner, like long corners. In those cases, just make sure you are ready for a possible micro-slide during the downshift itself.

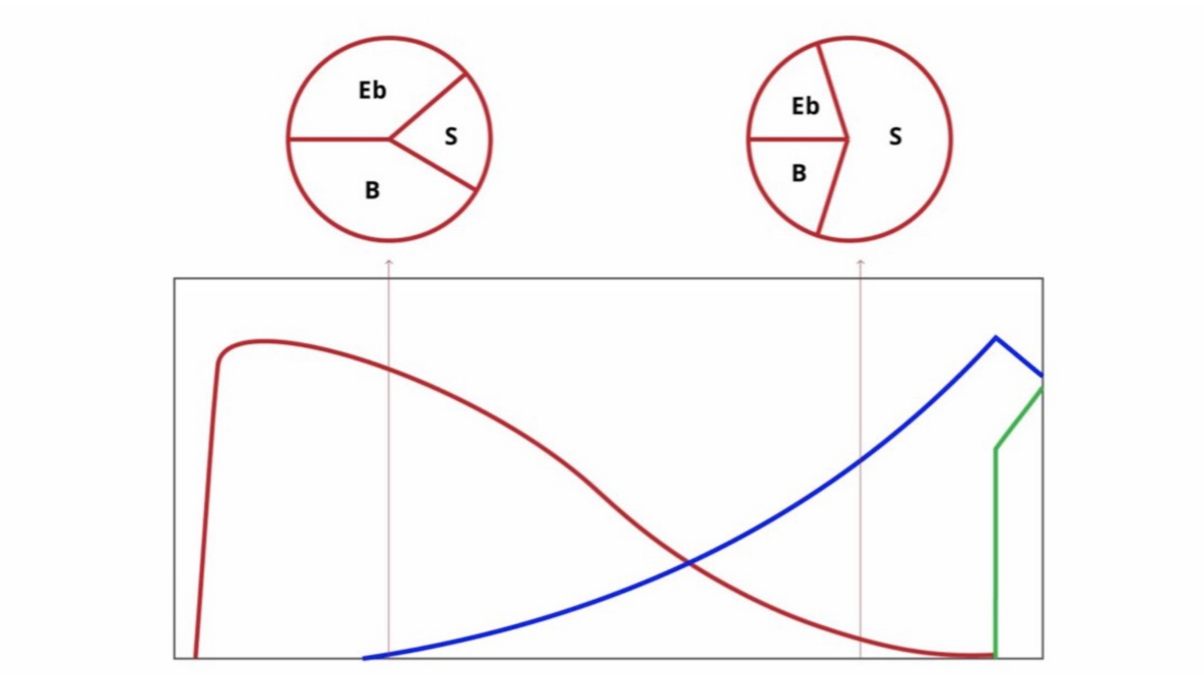
Summary

In short, the steering may generate the rotation, but the trail braking and engine braking will amplify that rotation. Now that you know that with the same steering you can have a car with opposite behaviors depending on what you do with the pedals and gears, pay some more attention to these other two tools when turning into corners. You will be surprised at how drastically they change the behavior of the car. This will unlock a new way of driving that gives you more options and more possible decisions to make when dealing with balance into the corner.

The proportion of these three tools will differ depending on the stage of the corner.

On corner entry, we should not use too much steering since the RPM are going to be high, causing more engine braking and consequently more rotation. We'll also still be transitioning from braking to turning, which means there must be some considerable braking going on, keeping the front tires loaded, and causing more rotation (unless you are braking way too hard and ABS engages on the front tires, which would cause *less* rotation).

When deep into the corner, towards the minimum speed point (which is also the Maximum Rotation Point), engine braking should have minimal effect since the RPM are low. In this situation we're not trail braking too much either since the braking pressures are already much lower. Because of that, the proportion of the three tools for rotation will be different.



> Engine braking (EB), steering (S), and braking (B) proportions of influence in rotation at different stages of the corner

In the next few chapters, we'll discuss how to make adjustments to each of these tools in the most efficient way, while keeping all four tires busy and generating good traction throughout the entire corner.

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1 Low percentages of throttle during corner entry to shift some weight to the rear.

10

ENGINE BRAKING IN FWD CARS VS RWD CARS

Engine braking is one of the most underrated tools to generate oversteer in RWD cars. It can be the difference between understeering on entry versus completely losing the rear and spinning the car. But what about front-wheel drive cars?

Engine braking in FWD cars versus RWD cars will have the *opposite* effect on rotation. Because the engine is connected to the front tires in front-wheel drive cars, it feels as if there is an extra amount of braking power to the car when off throttle. If the car is already on the limit of rotation, engine braking will actually *decrease* rotation at higher RPM, making it understeer when you downshift more quickly.

So, if you want to generate more rotation with a front-wheel drive car, downshift more slowly so that the front tires will have more grip available.

11

WEIGHT TRANSFER: A TOOL FOR ROTATION MANAGEMENT

The weight of the car is thrown around while we drive. We’ve all been in a bus where the driver suddenly braked hard and we were thrown forwards due to inertia. The direction we’re thrown tells us what tires will have more grip during that moment. While braking (in the bus, we get thrown forwards) the front tires receive the load transfer, compressing more against the track and gaining grip. While accelerating (in the bus, we get thrown backwards), the rear tires receive the load transfer, gaining more grip while the fronts lose that grip.

While driving, we can see the nose of the car squatting as we brake and lifting as we accelerate. Just think that the lower the nose of the car is, the more grip the front tires will have, and the higher the nose is, the less grip the front tires will have.

The most practical way to use weight transfer is by feeling how the *pedals* affect the rotation of the car, often a lot more than the *steering*. What you do with the pedals will affect how your steering will perform.

Weight Transfer Under Braking and Turning

Under light braking, some of your weight is transferred forward, “empowering” the front tires. This means when you steer under *light* braking, the front tires will be more capable of turning, increasing overall rotation.

Under *heavy* braking, the turning may reach the limit of the tire, causing locking and dropping grip effectiveness to zero immediately, causing the car to go completely straight.

We can then create three levels of braking effects on entry *while turning*:

First level (braking too light)

Causes a little more rotation since we're just bringing a little bit of weight to the fronts without causing too much stress.

Second level (ideal braking)

Causes a little bit of oversteer since we're right on the limit of the front tires, squeezing as much grip as we can from them, causing the car to rotate a lot more. In this second level, we are in the sweet spot of rotation for the front tires, and if we think the car is oversteering too much, we can simply release the brakes a little quicker to be closer to the first level. This will allow a little more rotation, but less than the second level. This is called **inducing understeer through brake release**. We'll discuss this a little bit more in the next chapters.

Third level (excessive braking while turning)

Causes tire locking and consequently total loss of grip.

In cars with brake bias towards the fronts but without ABS, the front tires will lock and immediately lose grip, causing the car to go completely straight.

In cars with brake bias towards the fronts and ABS, the front tires will engage ABS and lose grip, causing understeer, but the car will still turn a little since the ABS prevents full locking.

In cars with brake bias towards the rears but without ABS, the rear tires will lock and immediately lose grip, causing the car to spin.

In cars with brake bias towards the rears and ABS, the rear tires will engage ABS and lose grip, causing oversteer, but the car may still be catchable, since the ABS prevents full locking.

Weight Transfer Under Acceleration and Turning

Under light acceleration, some of your weight will be brought to the rear tires, increasing rear grip and decreasing rotation (since the front tires will be lifted a little and will be less capable of turning).

Under heavy acceleration (in cars with enough power for that), the rear tires may get too much stress and will start losing grip, causing wheel spin, more rotation, and even total loss of grip, snapping the rear tires, and causing a spin. We can then create three levels of throttle effects on exit:

First level (under the traction limit, no wheel spin)

Causes understeer as we're bringing some weight to the rears without causing too much stress.

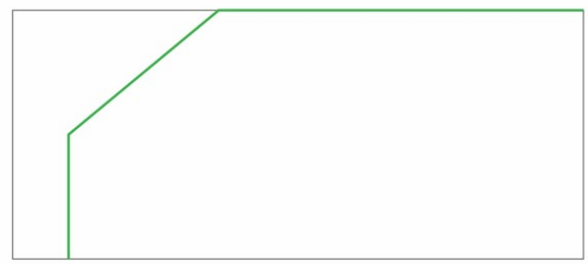
Second level (at the traction limit, edging wheel spin)

Causes a controllable oversteer since we're on the limit of the rear grip, while being able to make some micro-adjustments to maintain the car balance. This is the optimal level.

Third level (over the traction limit)

Causes loss of rear grip, wheel spin, and possible power slide/drift/spin since we went past the grip limit of the rears.

While these are the three possible effects of throttle application on the balance of the car, remember that some cars have too little horsepower and will be stuck between the first and second level, while some cars are powerful enough to be at the third level way too easily. Know your car and setup to know where these three levels sit within your throttle percentages.



> The throttle application trace in this image could be under the limit in a low-powered car, causing understeer, but way over the limit in a Formula 1 car, causing instant spin.

12

STEERING ANGLE VS STEERING FORCE

The car communicates a lot through the steering wheel. The steering input is traditionally measured in degrees of angle. You will most likely hear "I turn less than you" rather than "I turn with less force than you." In this chapter, I want to think outside the box and expand the ways we can communicate with the car. Before going further, let's dissect some concepts.

"**Gripping the steering wheel**" is how hard we grip our hands on the steering wheel itself. You can, for example, grip the wheel very hard while not turning a single degree. This is not efficient. Too much grip means less sensitivity to what the car is telling you, less precision when adding steering input, and it could hurt you. The other end of this spectrum would be "driving with your pinkies," which is well known advice from many coaches around the world that seeks to induce the driver to use *just enough grip*, no more. The Light Hands Technique will be discussed soon and will bring more detail to this concept.

"**Steering angle**" is the state of the steering at a given moment, measured in degrees, like 45º, 90º, etc.

“**Steering force**” is the force added by our hands and arms to initiate the movement of the wheel. Note that this is not the grip. We need to grip the wheel to be able to apply some force – just enough so our hands don’t slide around it.

Simply put, we add angle by using force. You grip the wheel, and to turn, you pull it down with one hand and push up with the other. Without force, the wheel does not turn. Add more force, and you’ll steer more quickly. Add less force, and it will turn more slowly.

This may sound obvious since we’re bringing some basic concepts to the surface, but you may develop extremely important habits in your driving if you think about these concepts more analytically. You may identify inefficient force applications and unnecessary tension as well as develop better sensitivity to understeer/oversteer mid-corner.

The benefit of thinking about steering *force* instead of *angle* is that this allows you to have a conversation with the car. You can know how much grip is available in the front tires by feeling how much the steering wheel is resisting to the input. When thinking about angle, you end up “overriding” this sensation.

13

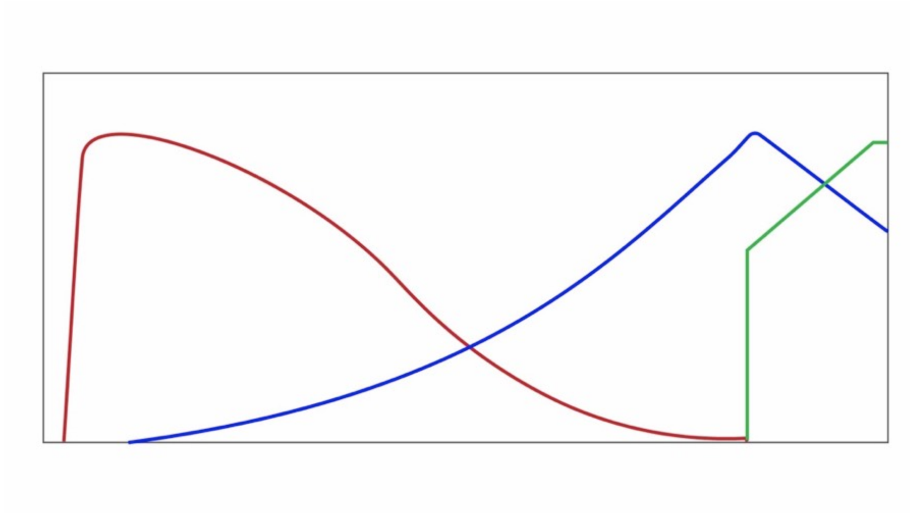
EXPONENTIAL STEERING VS LINEAR STEERING

Being free from the linear relation between brake release and steering might cause a little bit of confusion. You might ask yourself: what would be the ideal steering trace, then?

The most basic answer to this becomes the distinction between two types of steering input: exponential and linear.

Exponential Steering

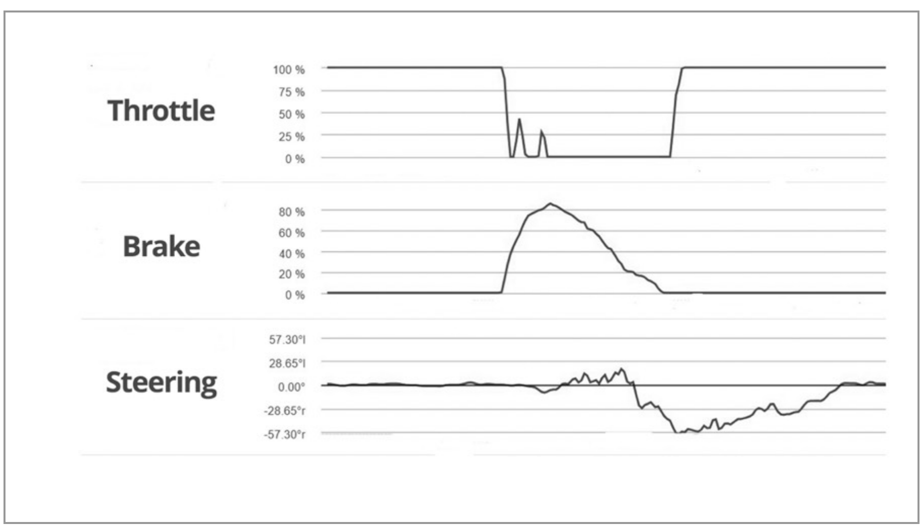
Steering input will be more progressive in cars with low downforce. These cars can't rotate well at high speeds and the V-shape nature of the racing line will show up in the steering trace. The initial rotation is going to be very progressive, following the elliptical trace of the V-shape line, but will increase at a higher and higher rate (or exponential rate) as the car slows down. Because of this, a low downforce car will most likely have a steering trace that looks like this:



Exponential steering

The Light Hands Technique allows you to find the ideal trace more naturally from car to car.

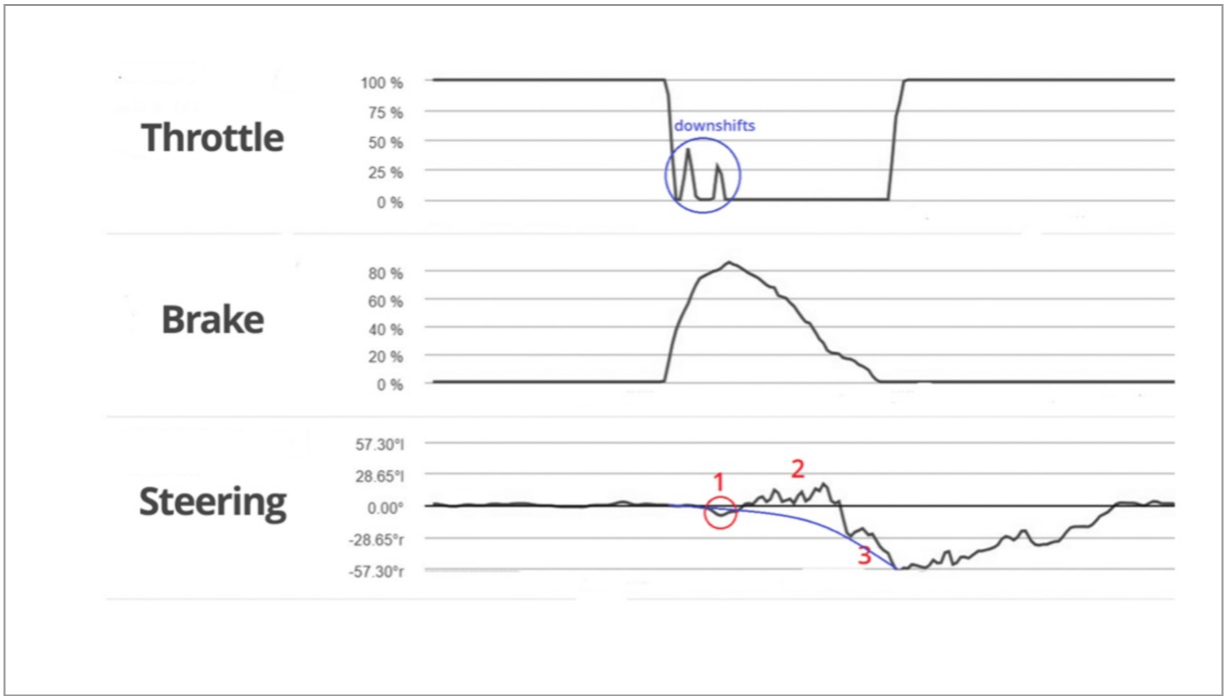
Some cars with aggressive engine braking reinforce the need for an exponential steering trace. This is because by the time you do the last downshift and turn into the corner, the RPM are still very high, causing a higher tendency to rotate. That is the most common reason a lot of cars tend to oversteer on early entry. As the speed decreases into the corner, so do RPM and the tendency for extra rotation.



Exponential steering. This is a more extreme example, with some slight countersteering as the car slides into the corner dancing between neutral steer and oversteer.

The example above will be re-used several times in the next few chapters, each with a different analysis or point of focus. The car used was a Ray FF1600, in iRacing, at Okayama, Turn 1. The corner was near perfect in terms of lap time, with good track usage, racing line, well-timed downshifting, and good braking and steering technique.

Okayama, Turn 1 (From the left to the right)

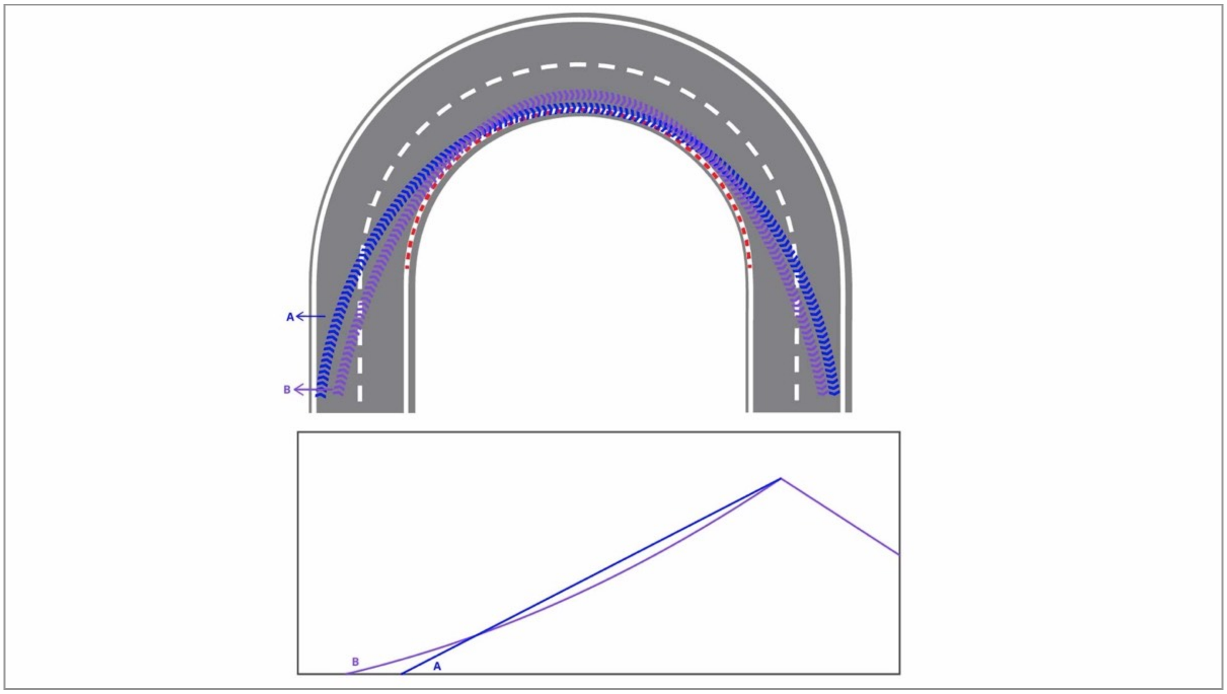


Above is a breakdown of the telemetry in that corner. Number (1) on the steering graph shows just a bit of initial steering (8 degrees to the right), which in combination with the downshifts, extra engine braking (blue circle on the throttle graph), and the peak braking, make the car point into the corner nicely. Since the car is already pointing well due to the braking and engine braking, some light countersteer is needed (2). The countersteering action (2) is maintained as the car points even more into the corner (yes, the car is gaining rotation to the right even though we're still turning very slightly to the left!). Finally, when the RPM and braking pressures are lower and the car is deeper into the corner, we add more steering to the right (3) as we're about to accelerate out of the corner and unwind the steering. The blue line on the steering graph represents the theoretical exponential steering line, which would be much closer to the actual steering telemetry in less oversteery cars.

Linear Steering

Cars with more downforce behave as if they had more weight force acting upon the tires (pressing them further against the track), without the downside of inertia that said weight would bring. This means that they can brake more, accelerate more, and turn more, the higher their speed.

Because of this, when a high downforce car approaches a corner, it can rotate more on early entry. This means we can start turning later into the corner, and the difference in rotation from turn-in to MRP will be much less noticeable than it is in low downforce cars.



Steering traces in high downforce cars (blue) versus low downforce cars (purple)

Since the car will accept more rotation on entry, the steering angle becomes less exponential. You’ll still turn slowly into the corner if there is braking, but the rate at which you increase the steering is higher on entry compared to low downforce cars.

I don’t like telling students how a trace *should be*. Instead, I prefer to teach students to feel the car and find approaches that will eventually lead to the correct telemetry trace. The next chapters about Light Hands Technique and inducing oversteer and understeer will show you how we can get the right driving inputs if we chase the right behavior from the car using our senses.

Camber and Elevation Changes

Remember that the steering trace will be affected by the corner characteristics. If there is a crest on corner entry, your steering will have to be gentler, but as soon as that becomes a compression or cambered turn, then you can add steering at a much higher rate. This will create unique steering traces for some specific corners. This is one of the reasons I don’t like telling students what to *do* and to instead look for the right *feeling* of rotation where they’re using all four tires at all times (neutral steer). The traces will have to adapt to these corners to make it happen.

14

LIGHT HANDS TECHNIQUE

The **Light Hands Technique** is a topic that I have mentioned many times leading up to now. A precise racing technique requires constant communication with the car. We don't just oversteer or understeer on a given corner. We can have multiple different states, all the way from entry to late exit, in a corner. In real life, the g-forces will give us information that can be used to assess the state of the car. The steering wheel, on the other hand, gives us information on the state of the front tires (and consequently on the rears as well) through resistance to turning.

Different cars can have a wide range of steering resistance. Cars with power steering will have much less resistance, while cars without power steering could have incredibly heavy steering wheels. In Formula 1, for example, the drivers have the option to choose the amount of power steering, so their steering wheel can be heavy enough to feel the car through the tires, but not so much so that it becomes difficult to endure for the full race. Cars with too much power steering may give you very little feeling, decreasing precision and sensitivity.

The Light Hands Technique is the ability to adjust the amount of force applied to the steering wheel. It does not necessarily mean to drive with extremely light and relaxed hands all the time, but rather to be aware that the force can vary depending on car, corner stage, and even state of the car (understeer, oversteer, tire locking, etc.).

Add less force on entry to induce the initial rotation with more precision. Add more force mid-corner to generate more rotation and "test" the amount of available grip, and so on. What matters here is being able to move this force slider up and down to feel the car as much as possible.

It is incredibly common to grip the wheel too hard. As a matter of fact, even with my extensive coaching and driving experiences, one of my coaches for Super Production Challenge pointed out that I was too tense and gripping the wheel too hard. It is possible to still be too tense even when we believe we're relaxed enough. Examine this with a magnifying glass since this technique determines the amount of communication that flows between you and the platform.

Drivers that grip the wheel too hard are most likely not thinking about the two other tools for rotation on entry: trail braking and engine braking. A driver that pays proper attention to all three tools will most likely have more relaxed hands, since they're necessary for the driver to feel the effects of trail braking and engine braking on the balance of the car. Tension hinders the driver from feeling the car.

The most important place to have your hands more relaxed is under hard braking and turn-in. In threshold braking, having the car balanced 50/50 left to right is necessary for maximum braking performance, and gripping the wheel too hard will prevent the car from naturally adjusting to the track surface, meaning you will have to make micro-adjustments to the steering angle. Or you'll be forcing the car to turn a degree or two without noticing, and the lateral balance of the car will not be 50/50. If you are pressing the pedal as hard as you can, a 1% shift in lateral weight balance can be enough to cause lock up on the unloaded side.

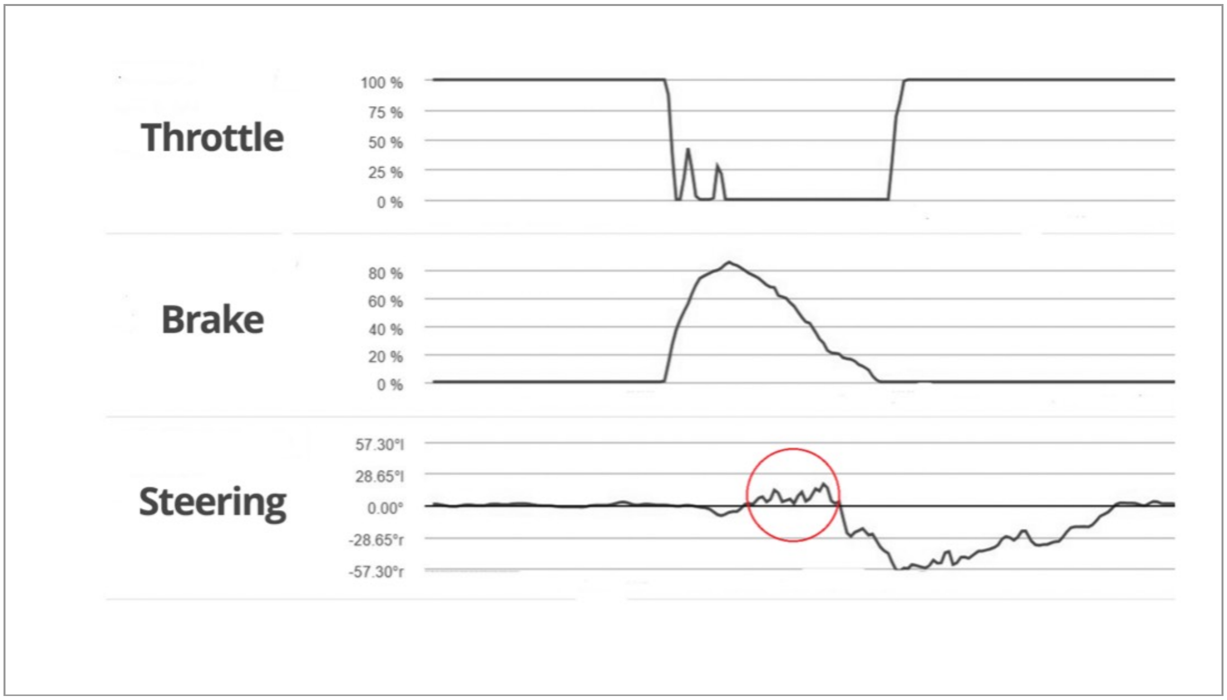
When turning in, you should still be braking a decent amount since you are starting to transition from braking into turning (trail braking). Because of this, the front tires will still be heavily loaded and stressed from the braking, which makes the car very sensitive to steering. Steer too much on turn-in with tense hands (gripping the wheel too hard) and you might get excessive rotation, spin on entry, or lock the rear tires (also spinning on entry) or the front tires (making you lose rotation and go straight if you lock both front tires). Steer with light hands and you'll feel the effects of trail braking and engine braking during the initial rotation of the car.

The most practical way to apply this technique is the following: **The harder you brake, the lighter your hands should be**. When turning in, turn only enough to feel the car responding to the turn. If you want to experiment forcing the rotation a little more, try to do it at lower speeds first, then doing it at higher speeds, progressively.

Light Hands Technique – Countersteering

The Light Hands Technique allows you to feel precisely when the car starts oversteering. More important than that, with light hands you can allow the natural resistance of the steering to bring the car back to centered without the need of active intervention from the driver.

Passive countersteering happens when the steering wants to turn itself in the other direction on its own because of the forces that come from the contact between the tires and the track. The wheel will be drawn back to the center when not oversteering (self-centering) but will be turned past center and in the opposite direction when oversteering (passive countersteering). This effect is much stronger in cars without power steering. In these cases, the driver generally never needs to deliberately turn back to a straight line (using active force) since the passive countersteering force is higher than the turning force from the driver. The immediacy of the physics makes this effect happen with absolutely no delay and with no need of human intervention.



Ray FF1600 at Okayama, iRacing

The example above shows passive countersteering. Although the steering is pointing slightly to the left (red circle), I'm still adding force to the right – towards the inside of the corner. I'm fighting against the natural feedback of the wheel, allowing it to make the corrections the car is requesting due to oversteer. This allows me to countersteer very precisely and immediately without losing the racing line or going wide. Passive countersteering is only possible when the amount of oversteer is subtle, which means you need to be very close to the perfect limit for it to be effective.

Active countersteering is a direct action from the driver to turn the steering the other way. It should happen when the driver senses oversteer and needs to take action to correct the slide.

Active countersteering depends on a person's ability to react. For reference, Formula 1 drivers have a reaction time of around 200 milliseconds.

Practicing the Light Hands Technique enough could move the number of corrections in your driving towards the passive countersteering realm.

Active countersteering is a disruptive action and has many downsides when overdone, like changing the line of the car towards the outside. Active countersteering may be necessary in some cases (call them Holy Sh*t moments), but they must be minimized.

Try to do some laps on the simulator and identify if your corrections are active or passive. If your wheelbase is not powerful enough, like 2Nm, you will probably make almost 100% of your corrections actively. As soon as you get around 6Nm or more, it becomes easier to allow the steering to make the corrections on its own, and you can then work on your passive countersteering skills.

The benefit of passive countersteering is that the driver needs to do less work, leaving space for more precise driving and better lap times. Doing passive countersteering while gripping the wheel too hard is impossible.

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LIGHT HANDS TECHNIQUE PART 2

KEEPING THE FRONTS ENGAGED ON ENTRY

As we gain precision with proper steering force and the Light Hands Technique, we become more capable of adjusting this force in each stage of the corner. But until we find the perfect amount of steering force, we keep alternating between too little force and too much force.

When we start oversteering with the hands being overly relaxed, the passive countersteer might bring the steering back a little bit too much, which puts the car under the limit.

Keeping the fronts engaged at all times is crucial to maintaining 100% grip usage. Think about it: every time we make an oversteer correction with countersteer when the front tires are pointing away from the corner, we’re only using 50% of the available grip in that fraction of a second (since the rears are on the limit but the fronts are not), and the front tires are moving the car away from the ideal line.

So, we need a solution to keep the fronts pointed *into the corner* at all times. That solution is inducing understeer. We can do that with the pedals. The pedals have the power of transferring grip back and forth, enabling or disabling grip from each end. In this case, we can induce understeer by shifting weight back to the rear tires, decreasing the grip on the front tires even while keeping the same steering angle. This is one of the most important tools to make sure we’re always using all four tires as much as possible.

Let’s summarize:

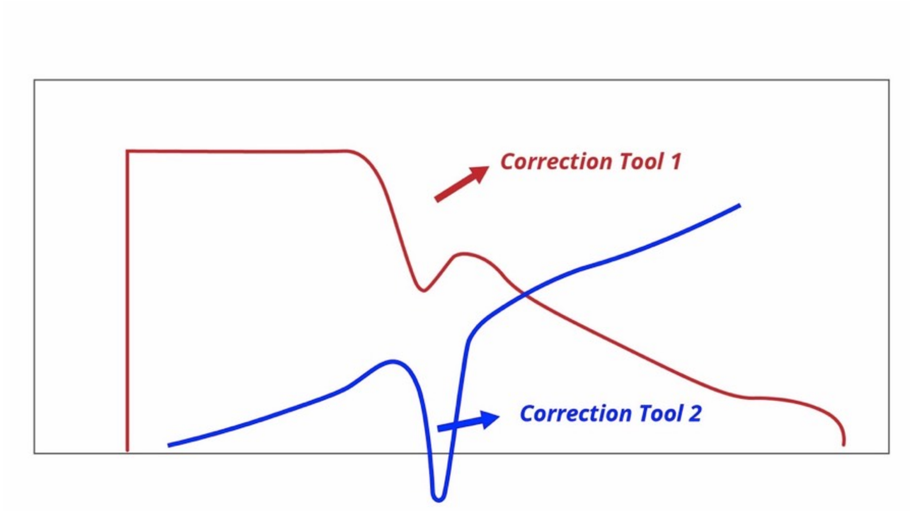
During entry the car oversteers. It is using 100% of the available grip but starting to slide and needs to be corrected.

Correction Tool 1

By inducing understeer with pedal release or some throttle, the car will correct the slide but keep turning into the corner. The grip usage is at 100% and the car stays close to the racing line.

Correction Tool 2

countersteer so the car points out to correct the slide. The grip usage is at 50% and the car loses its line and goes wide.



Inducing understeer (Tool 1) is the most efficient tool and must be a priority, but it might not be enough. When sliding, we can combine both tools to maximize lateral traction. We want all tires to be creating a force towards the *inside* of the corner. If you passive countersteer very gently where the front tires are still pulling the car into the corner, you are still using 100% of the grip. The problem appears when the countersteer is too big and the fronts stop creating the lateral force towards the inside, starting to point away from the corner.

You can create a muscle memory programming that looks like this:

1. Try to keep the fronts as loaded as possible and rotate the car.
2. If the car is oversteering, try to release the brakes more quickly to induce understeer (Tool 1).
3. If that's not enough, micro-countersteer using passive countersteer (Tool 2).
4. If that's still not enough, actively countersteer (aggressive Tool 2). This should be the last resort.

This all takes place within a fraction of a second. After being properly trained, this will become an unconscious reflex.

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LIGHT HANDS TECHNIQUE PART 3

KEEPING THE FRONTS ENGAGED ON EXIT

On corner exit, we have the following tools to make sure the car is 100% loaded, in order of priority.

1. Throttle modulation: We want to keep the car in the second level[1] range (medium acceleration) to maintain the rear tires at the edge of traction (almost wheel spin).
2. Slight passive countersteer: We use the Light Hands Technique to allow the fronts to make micro-corrections without having them point too much to the outside.
3. Active countersteer: We are sideways and we need to point the front tires totally to the outside (grip usage now down to 50%) to correct the power slide, which is not efficient but is necessary to save the car from spinning.

As you can see, we can still think about the front tires even on corner exit, since they'll have an important role in finalizing the lateral traction as we gradually decrease rotation. A power slide (generating rotation through acceleration and inducing oversteer through wheel spin) is slower because the rear tires are used excessively, losing traction and corner exit speed.

Tools 1 and 2 are the best in most instances. The third tool should be used minimally. We can induce understeer with the throttle by having less throttle application and staying closer to the first level (under the traction limit and no wheel spin), or we can induce oversteer by having more throttle application and going over to the third level (over the traction limit), which is almost always a bad idea.

On corner exit, it's okay to use the Light Hands Technique more to allow for passive countersteer. Perfect exits generally include the steering being totally straight while the car is still rotating a bit with the help of the throttle.

Inducing Understeer

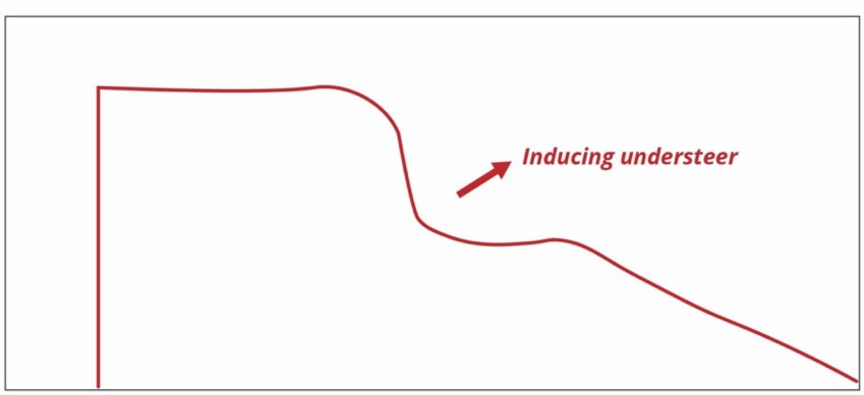
To induce understeer, you need to remove grip from the fronts while adding grip to the rears. We do that by transferring weight to the rear tires using one of the following tools:

Releasing the Brakes more Quickly

This is the very first tool we'll use on corner entry when trying to induce understeer. When trail braking, we determine the amount of weight traveling back to the rears, and the rate at which the fronts will lift. Release the brakes quicker and you'll quickly unload the front tires, decreasing their grip while increasing the rears' grip. This will create resistance to rotation, inducing understeer on the car immediately.

Be careful: cars with very light brakes and ABS might give you the sensation that releasing the brakes makes them rotate more. The reason is simple – with too much braking, we're activating the ABS on the front tires, which decreases rotation. When we release the brakes, ABS stops, which makes the car rotate more. Releasing the brakes further from that point would then cause the effect described here.

The harder the brake pressure required, the easier it will be to induce understeer through brake release.



Turning in very Quickly

Turn in too quickly and you'll immediately make the fronts scrub. They will try to rotate the car at a rate at which they're incapable, causing understeer.

The funny thing about this tool is that this is what almost all students do when I ask them to spin the car deliberately in the simulator. They say "sure, it's easy!" and proceed to flick the steering into the corner expecting to spin, but immediately getting heavy understeer. They accidentally induce understeer while trying to induce oversteer. The fronts are almost never capable of throwing the rear of the car that quickly. The car is a heavy metal box and requires proper "rotational acceleration" to be able to throw the rear around and spin.

Adding a Little Throttle on Entry

Also known as maintenance throttle, this technique consists of applying a tiny bit of throttle to bring some weight to the rear tires – 5~15% pressure would do. Drivers apply maintenance throttle in cars that oversteer too much – to the point they still oversteer even when coasting – so in these cases the throttle tames the rear. This technique should not be overused. It decreases trail braking efficiency and generally causes too much understeer in most cars.

Adjust the string theory's speed by releasing the brakes and steering more quickly and the car will most likely understeer, since it will be attempting to turn quicker and at the same time have less grip available on the fronts. A quick release of the brakes also feeds the rear with a lot of grip, and they resist rotation. In other words, steering too quickly while releasing the brakes too quickly will cause understeer.

> EXERCISE:
> Understeer deliberately in the simulator. Try to make the front tires scrub and carry that state of understeer around the whole corner. Try

doing this while staying as close as possible to the racing line. This exercise will force you to pay more attention to how much speed you are carrying into the corner and will help you feel how you can alter the racing line with the pedals, while keeping the steering cranked.

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1 See chapter Speed of Throttle Application Towards Traction Limit for more information.

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INDUCING UNDERSTEER TO CORRECT OVERSTEER ON CORNER ENTRY

Is it possible to induce understeer to control rotation?

When we oversteer on entry, our instincts tell us to immediately countersteer. It's a reflex: we see that the car is pointing too much to the inside, so we correct it by pointing the steering wheel the other way. We generally do this while still trail braking, which keeps the front tires loaded.

This is not necessarily the most efficient way to correct the oversteer, though. There is a better way: **induce understeer through brake release**. We can induce understeer through the pedals, trying to leave the steering as is, still turning into the corner. Why is this way better? And why do this instead of just countersteering?

In an ideal world, we always use 100% of the grip. That means both the rears and fronts are engaged, scrubbing, and supporting the platform laterally. When we countersteer, we are telling the fronts to *stop working*. We're telling the fronts to stop supporting the car and let the front point back towards the outside. During the fraction of a second we countersteer, we're using only 50% of the grip available (only the rears). Although this works and corrects the oversteer, you end up losing the line and going wide. When you get an oversteery car, it's challenging to keep the fronts loaded. You have to stay active (remember?), making corrections every fraction of a second to try to keep not only the rear tires, but also the fronts, on the limit, with vectors pointing towards the inside of the corner on entry.

When we induce understeer through brake release, we are sending more weight to the rear tires (which are the ones that needed more grip in the first place – remember, we're oversteering), while keeping the front tires engaged. This decreases the amount of grip on the front tires, correcting the oversteer, while at the same time keeping the front grip usage at 100% during the entire corner entry phase.

Inducing understeer is a light correction. It can correct micro-oversteer, but it won't work if the oversteer is bad.

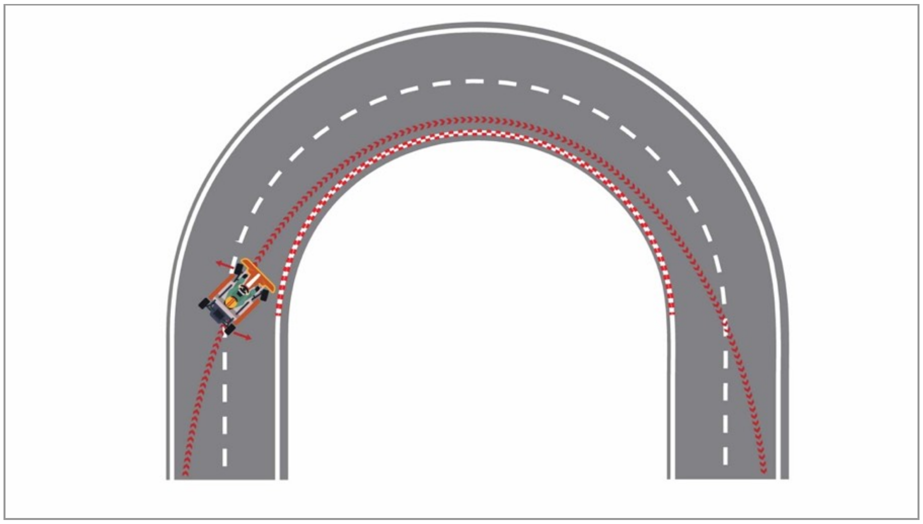
Countersteering is an aggressive correction. It should be used when inducing understeer is no longer effective due to the severity of the oversteer.

These two corrections can work together. It is a fine art to find the balance between both. Ideally, the order of priority will always be to induce understeer through brake release first and then start countersteering (roughly some tenths of a second after the inducing understeer attempt).

This type of correction is one of the most secret and powerful techniques in motorsport. With it, you can correct the balance of the car while maintaining the grip on all four tires to as close to 100% as possible at all times. It's also one of the most difficult techniques to master in real life, since it requires fast reaction times, incredible precision, and fearlessness. Inducing understeer through braking release is the pinnacle of the trail braking technique.

Imagine that you are looking for the perfect balance. You trail brake heavily into a corner, and the car develops a little bit of oversteer. What is the first thing we think about to correct it? countersteer. It works. You proceed to correct the oversteer and then turn the steering back to keep the car rotating.

I want you to pay attention to one small detail. I mentioned "turn the steering back," which means we need to re-engage the fronts to turn the car… which means we stopped using the fronts to correct the oversteer! Because of that, we had brought our grip usage from 100% to 50% for a fraction of a second (the duration of the correction).



Correcting oversteer with countersteering causes a loss of grip efficiency and the car slides more to the outside of the corner than optimal. Think of doing a big slide and catching it. What happens with the direction of the car? It stops turning since we're now so focused on saving it that we lose the ideal racing line. The same thing happens on a smaller scale when we have a little bit of oversteer and correct it with a little bit of countersteer.

Okay, so countersteering to correct oversteer is bad. What should we do, then?

We induce understeer with the pedals, releasing the brakes a little quicker, or, in some rare cases, adding a little bit of throttle.

That means we're using the pedals to bring the weight balance of the car towards the rear tires and correct the oversteer. When we do it that way, we can keep the front tires engaged and turning into the corner, maintaining our racing line as close to optimal as possible. When you master this technique, you can alternate between understeer and oversteer with just your pedals, without affecting the steering.

It's not always going to be that easy, though. When the oversteer is very subtle, inducing understeer with the brake release is the best way to go. But if the oversteer is bigger than expected, only releasing the brakes will not be enough, and brake release and countersteering will have to join forces. We can then create an order of priority for corrections.

When the car starts oversteering:

1. Release the brakes a little more quickly to shift more weight to the rears and induce some understeer. At this point, keep turning into the corner and increasing the angle as the car slows down towards the MRP. Remember that this needs to be done carefully, as releasing the brakes too much may make the car carry excessive speed into the corner.
2. If the brake release alone doesn't solve the oversteer, the car should start some passive countersteering (which is a more aggressive correction that tells the front tires to stop turning the car, therefore turning off the fronts' grip for a brief moment). Remember that even the countersteering can be incredibly subtle if you can rely on passive countersteering (using the Light Hands Technique). Think of passive countersteering when you see onboards of drivers turning into a corner with a small input and then straightening their wheel as the car turns in even more. Looks like magic, right? That is just oversteer and some passive countersteering to keep the steering in the right place.
3. If passive countersteering is still not enough and the car is still oversteering (at this point, 3 or 4 tenths of a second should have passed), you should actively countersteer to correct the car more aggressively. At this point, the car should be drifting more and more towards the outside of the corner, which is sub-optimal.

These corrections should almost always be made in this order of priority, and the decision to actively countersteer when passive countersteer fails should happen in a matter of tenths of a second. Because this happens so quickly, it cannot always be done consciously. This is a skill that needs to be trained as a reflex and will eventually become automatic in your driving.

This method won't work for all cars. Some cars will start understeering as you release the brakes and lift the fronts, but other cars can have the exact opposite effect. The reason is setup. Some cars with aggressive ABS and too forward brake bias will make the fronts lose grip with trail braking (since the brakes will be abusing the front tires more than the actual weight transfer that comes with it) and releasing the brakes will actually "let the fronts breathe" a bit, causing more rotation. This is far from ideal, since you end up gaining rotation while being unable to control speed, causing understeer to snap oversteer on entry. Cars that are set up this way are more difficult to drive, since when you release the brakes, the car will get more rotation than you expect, and you will have to countersteer anyways, decreasing efficiency on the front versus the rear tires.

When testing a new car, you must quickly identify how the car reacts to brake release while turning into the corner. To recap:

- In some cars, quicker brake release with heavy trail braking into the corner causes more rotation.
- In other cars, quicker brake release while trail braking into the corner causes less rotation.

Opposite effects. Make sure you find which one suits your car setup so you can better predict the behavior of the car. The inducing understeer technique only works in cars where releasing the brakes will decrease front grip.

Remember that engine braking from downshifting will change the car's rotational tendency. Higher RPM on entry may cause the car to rotate more, so make sure you are always adding up every possible factor that might be affecting the balance of the car to prevent unpredictability and inconsistency. Always remember the three tools for rotation on entry: steering, engine braking, and trail braking. They are the three pillars of car handling in motorsports.

18

TRAIL BRAKING – MAKE THE CAR ROTATE OR LET THE CAR ROTATE?

Trail Braking can feel very different from car to car when it comes to rotation management. Some cars feel like adding brakes will make them rotate more, while others feel like braking while turning will make them rotate less. This happens because as soon as we reach the limit of grip (longitudinal + lateral), the excess braking stress can have a stronger effect on the front or rear tires, depending on the car setup, suspension geometry, and brake bias.

Yes, forward weight transfer will always transfer more load to the front tires, but sometimes the geometry of the chassis or brake bias will make more braking density mean less cornering grip to the front tires – enough to compensate for the higher grip from the weight transfer, accounting for a lower total grip difference, and causing the car to understeer with more braking pressure.

Let’s recap a few effects of braking while cornering.

1. The weight transfer, which increases the load on the front tires and decreases the total load on the rear tires. The effect of weight transfer under braking is more grip on the front tires, allowing for more rotation.
2. The stress caused by the braking itself (creating longitudinal slip). By isolating this stress from the weight transfer, we can have two possible effects on the rotational tendency. Let’s analyze two

extremes, for clarity purposes, which would be 100% brake bias on the front tires and 100% brake bias on the rear tires.

3. With 100% brake bias to the front and 0% to the rear, the stress would be so high that it would be very easy to lock up the front tires, making the car go straight. This effect is contrary to the benefits of weight transfer to the front tire grip, and in this extreme example it would completely cancel the extra grip from the weight transfer, making the car understeer even before completely locking, and go completely straight as soon as the two front tires lock completely (if we added even more brakes). Reaching ABS on the front tires first has the same effect as drastically decreasing the amount of rotation the car is capable of doing, causing understeer.
4. With 0% brake bias to the front and 100% to the rear, the stress would be totally concentrated on the rear tires, decreasing the grip even more on the rear while allowing the front tires to use all the available grip for rotation. In such a situation, the car will already rotate more with braking even before locking, and then completely spin as soon as the rear tires lock (if we added even more brakes). Most karts only have rear brakes, which is why they are so prone to rotation under braking. In this situation, the weight transfer and the braking work together to create a huge difference in lateral grip between front and rear.

Most cars will have the front brake bias in the 50-65% range. The higher this number, the more we feel that we let the car rotate with the brake release. The lower the brake bias, the more we feel that we make the car rotate with the brakes applied. This is a very subtle topic, because the difference between *making* it rotate and *letting* it rotate can be very subjective and two different drivers can have opposite feelings in the same car, depending on how heavy their braking density tends to be while turning.

Another factor that influences the “make it rotate” versus “let it rotate” sensations is the brake pedal resistance. If the car has brake boosters and you can reach ABS easily without a lot of brake pressure, it will almost always feel like you have to release the brakes to let it rotate, since it will be very easy to just be over the limit (and most cars have the brake bias towards the front for safety reasons). But if the brake pedal is very heavy and requires high pressures to work, you will have a bigger range of pressure to work with on turn-in, which might make it feel like you are making it rotate.

It's important to note that it's still possible to lock the fronts and understeer mid-corner even if your brake bias is low enough to lock the rears on a straight line. Be careful with this. If you change the brake bias in order to gain more rotation mid-corner and ignore the effects on a straight line, you might lock the rear tires on initial braking and spin.

Trail braking in stiff cars, like Formula cars, can be tricky. If you trail brake too hard, imagine that you are "choking" the front tires, and they can't breathe – they lock. This can happen even if you have a low brake bias. If this is happening, then let the car rotate with less trail braking density. Let the front tires breathe and they'll give you more rotation.

19

INDUCING UNDERSTEER TO CORRECT OVERSTEER ON CORNER EXIT

On corner exits, we'll also have an order of priority to make sure we're optimally using all four tires.

Let's say we hit our MRP and start accelerating. We're dancing around the traction limit of the throttle while turning (for example, 80% throttle). The car starts oversteering a little bit. What should you do? countersteer first? Lift the throttle first?

We'll follow a similar procedure to the one we used on corner entry: we want to keep the fronts engaged as much as possible, so countersteering will always be the second or third priority. The first priority is to lift slightly off throttle (around 10 or 20% less pressure) to decrease the stress on the rear tires and correct the oversteer. If the oversteer is still not solved, then we go back to the passive countersteering to active countersteering order of priority mentioned previously.

Of course, this is assuming you are already on the optimal line for the exit. This example considers that we don't have any extra space and that we need to keep on that elliptical exit line (losing rotation progressively, while still staying on the limit all the way to the late exit). If there's more room on exit, you should then just lighten up your hands and allow the car to use the whole track on exit while maintaining the throttle modulation.

I see a lot of students trying to accelerate too hard out of the corner, causing wheel spin and oversteer. They then countersteer, losing the line and going too wide. Because of this, they end up having to lift the throttle to prevent going off track or hitting the wall. All this can be prevented if the correction is done through a small release in throttle while minimizing countersteer to keep the car on the right line.

Remember to always focus on correcting the balance with your pedals before moving on to aggressive steering corrections.

20

THE PROBLEM WITH BRAKE RELEASE FOR BALANCE PURPOSES

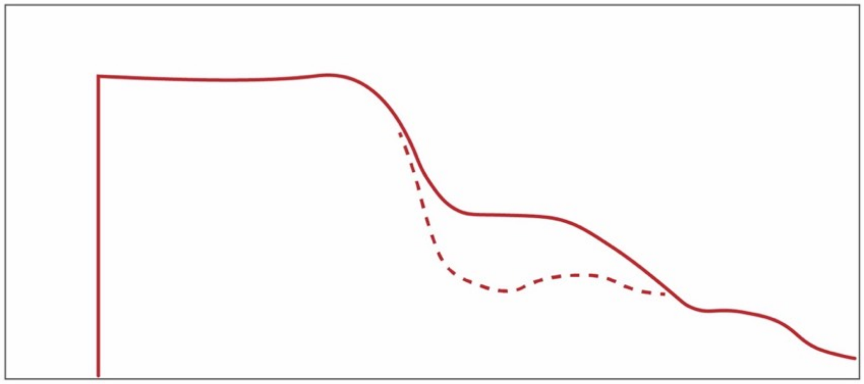
The primary function of the brakes is deceleration. When we start managing the brakes to balance the car, we end up affecting the deceleration as well. This creates a double reaction, which will affect the speed for that corner.

For example:

1. If the car is understeering and we use a more aggressive trail braking technique to make the car turn more, the extra brake pressure will also decelerate the car more, decreasing minimum speed.
2. If the car is oversteering and we release the brakes to induce understeer, we end up carrying more speed than expected, affecting the exit line and preventing us from committing to the throttle application.

In motorsports, one change in approach could force many other factors to change too, like braking references, turn-in points, and acceleration points. When experimenting with inducing understeer and oversteer with brake release, keep your senses open for further adjustments that may be necessary to make the new approach work.

The bigger the braking correction for balance purposes, the more the speed will be affected. The perfect trail braking technique has the least amount of corrections possible, keeping the intended entry speed similar.



Be careful not to fluctuate a lot in brake pressure when making corrections. This will prevent you from feeling the subtle effects of smaller brake release attempts.

21

FISHING THE GRIP – DEALING WITH OVERSTEERY CARS

When the inducing understeer technique is not enough to correct excessive rotation in the car, keeping the fronts engaged without losing the rear becomes impossible. If the car is too loose, the amount of brake release needed to make the car rotate less is so high that the car would not decelerate at all (0% braking mid-corner = coasting), and braking would have to be done mostly in a straight line with a sudden brake drop to shift weight to the rear tires on entry. This would force the turn-in to be quick in order to keep the front tires optimally engaged, which goes against the optimal elliptical line. This would also force the turn-in to be later, creating a “square” abrupt turn-in. This approach works well in light cars that manage a high amount of slip angle, like karts or entry-level Formula cars.

In most cars, in order to trail brake optimally and keep the elliptical line, we have to gently control the amount of steering input to manage the rear tire slip manually with the steering. This means we will *not* squeeze everything from the front tires on turn-in right away as trying to turn-in more would make the rear snap out. Instead, we turn gently (with less steering force) and manage the rear tires through the steering. This is what some call “**fishing for the grip**,” as the driver needs to be actively judging the rear slip, adding more steering angle as speeds decrease to keep the lines elliptical until the Maximum Rotation Point, and keeping the rears healthy.

Fishing for the grip is a technique that naturally occurs in drivers who drive relaxed. Death-gripping the wheel will make this technique incredibly difficult and even more tiring.

22

COMBINING HANDLING TECHNIQUES IN RACECARS

What makes driving at the limit difficult is the fact that we can adjust many separate inputs, all of which affect the bigger picture. While you can try to alter just one input and see how the car reacts to it, when sending it you will need to make different adjustments in different combinations and proportions to compensate.

Trial and error will always be the easiest method to find these behavior changes and decide the ideal approach (for example, whether you should release the brakes more quickly and barely trail brake, fish for the grip with the steering while still trailing the brakes heavily, or a little bit of both).

Remember to always try to move from understeer to oversteer progressively, as this will keep you safer from losing the car too quickly. If you are trying to test the front grip, a little maintenance throttle (5-20% throttle) or total coasting (0% braking) may ensure the rears are loaded so you can progressively feel the balance starting from the safe side. Starting with understeer is always the way to go. Then, you can start adding grip to the front tires until the rear tires start to let go. Finally, you try to stay in that middle zone, the neutral steer.

23

INDUCING OVERSTEER ON ENTRY – CAN YOU SPIN THE RACE CAR DELIBERATELY?

We know we're optimally using the steering into a corner when the trail braking increases the rotation of the car even more. This happens when our front tires are on the perfect slip angle. Because we're slowing down the car as we turn in, this perfect slip angle (and consequently perfect steering angle) will be a moving target. There is a magic combination of steering and braking (that is also a moving target, changing as the car slows down) that will make the car rotate more. Indeed, it can rotate so much that we can get the car to spin. Different factors will affect this rotation, like engine braking, car setup, and brake bias. Depending on these factors, it may be very easy to induce oversteer with trail braking, or it can be virtually impossible.

A good exercise is to try to find this magic combination and get the car to rotate a lot (even spinning, if you are trying on the simulator), and then back off the brakes just enough to have a controllable oversteer into the corner. If you are just on the edge of oversteering (or neutral steer), that means you are pretty much on the limit and you have found the ideal cornering speed for that radius. If you are using the whole track and you manage to get that rotation all the way around the corner, you are at a good limit.

This exercise (spinning the car on entry) will help you develop a skill called **inducing oversteer**. It is easier to do in cars with a lower brake bias. If you are trying to do this in a car with ABS and a brake bias that is too high (towards the fronts), you'll most likely end up understeering first.

If you notice that the car is turning so much that you are hitting the inside of the track too early – bingo! You unlocked extra turning capability and you can carry a little more speed into the corner on the next lap.

Tip: Inducing oversteer works when you steer a little less than you think. The goal of this exercise is to get the car to rotate as much as you can with as little *steering* as you can. Inducing understeer, on the other hand, is the opposite – trying to make the car rotate the *least* amount possible while using a very high steering angle.

In short:

- Induce oversteer: Less steering, more rotation (and the source of the rotation comes from brakes and engine braking).
- Induce understeer: More steering, less rotation.

Normally, when you oversteer too much because of this exercise, the solution is to start releasing the brakes as the car gets into this extra-oversteery state, or inducing understeer. You induce understeer when you release the brakes more quickly at a given micro-moment to shift more weight back to the rears, feed them some more grip, and regain the balance of the car. If you try to do this too late, though, you will end up crossing the point of no return, which is when the car oversteers too much and spins. You can also induce understeer using the throttle with the maintenance throttle technique. This consists of small throttle inputs to shift even more weight to the rear tires when the release of the brakes isn't enough. Be aware that this technique must be a last resort as it can decrease braking and trail braking efficiency in cars that don't require the technique. Maintenance throttle is used mostly in cars with an open differential on the rear tires.

Inducing understeer and oversteer can happen several times in a single corner. You'll basically "dance" with the car through the brake pedal inputs. Slower brake release means more rotation. Quicker brake release means less rotation. You'll find the right balance after practicing this for a while. The more you practice, the more you'll gain the reaction speed to play with the car on the limit without being afraid of spinning.

24

SPEED OF THROTTLE APPLICATION TOWARDS TRACTION LIMIT (SECOND LEVEL)

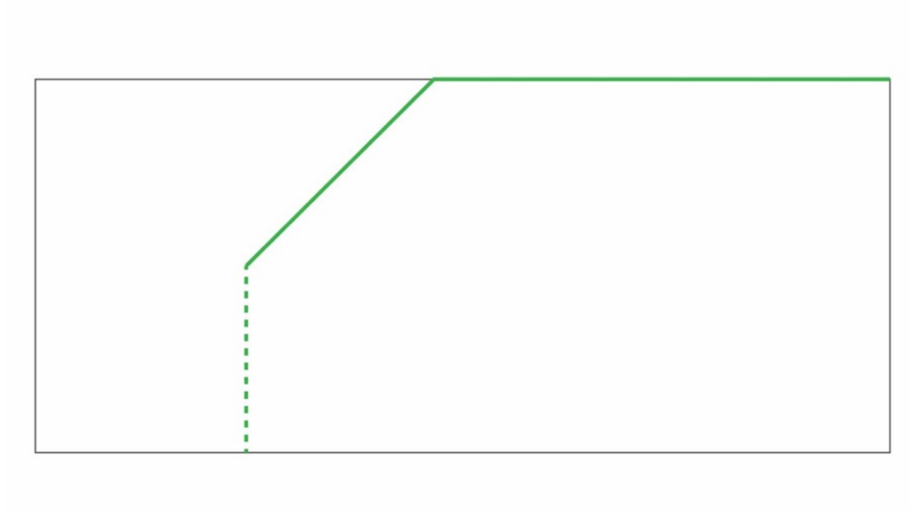
Speed of Throttle Application

"Squeeze the throttle" and "smooth is fast" are two sentences that beginners hear a lot. The reason is simple: the phrases are intended to explain ways to prevent excessive wheel spin on exit upon throttle application.

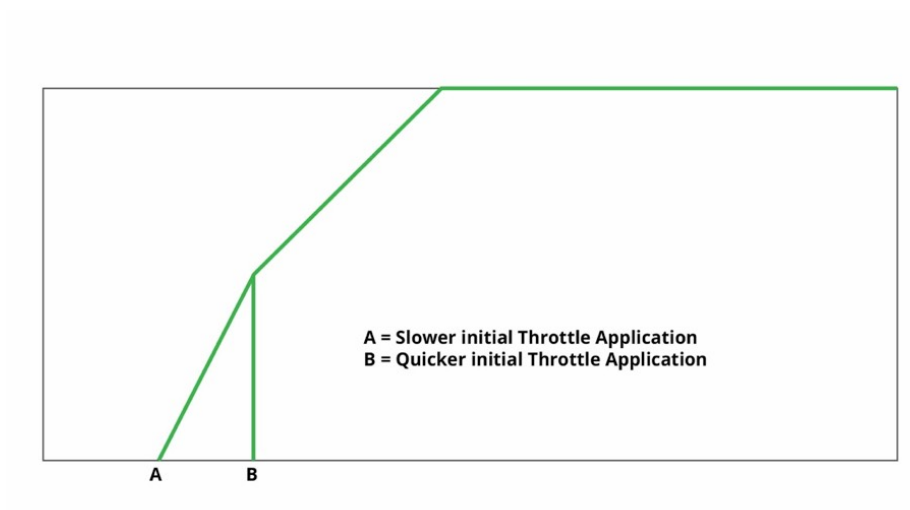
Now that we know that we have three levels of throttle application, we can be more specific about how the throttle application should be done.

We don't want to get into the third level (excessive acceleration) at any time, since the wheel spin makes us lose traction in both ways (laterally and longitudinally). We also don't want to get into the first level (light acceleration) and cause unnecessary understeer. Level two (ideal acceleration) is difficult to find at first, as it has a much smaller throttle percentage range than the other two.

Although we can quickly learn how to avoid the third level (excessive acceleration), it's very easy to think we're nailing the ideal throttle percentage. The issue is not necessarily the percentage itself, but how quickly we should get there.



Let's say that at the apex of a given corner, the ideal throttle percentage to maintain perfect rotation is 50%.



How quickly we go from 0% to 50% will impact the behavior of the car. Some cars will keep the ideal rotation if we smash the power straight to 50% as quickly as possible, but others will oversteer if this is done. Other cars prefer a smoother application to the 50%. That speed must be found through trial and error. This also depends on how the car handles weight transfer, which can be heavily affected by car setup, for example.

If you are an intermediate or advanced driver, you might already find the second level with ease. However, it's likely that you never thought too much about that fraction of a second between 0% and the ideal throttle percentage. If that's true, that means you probably apply the throttle at the same speed in all cars. For some cars, that may end up being perfect, but for others, you may be losing some hundredths on every exit. Try different speeds of throttle application and see how the car behaves. If you get the car to rotate just a few degrees more without getting into oversteer, boom! You just gained some time.

Throttle Application in Different Horsepower Ranges

Perfect acceleration comes from reaching the traction limit right before wheel spin and maintaining that as you modulate the throttle upwards and exit the corner.

Reaching the traction limit will depend on how powerful the engine is, and how quickly the torque is transferred into the wheels.

Below you will find a good visualization of what perfect acceleration would look like across different cars.

Remember that we have two ways of adjusting the throttle application:

1. **Initial application to traction limit**. This will mostly determine balance. A quick kick in this initial application might give you a little more rotation. If this rotation is accepted by the car, it should be the preferred method.
2. **Modulation of that traction limit**, when reached. This is to keep the car on the very limit before experiencing wheel spin as the car gains speed and loses rotation during the exit phase.

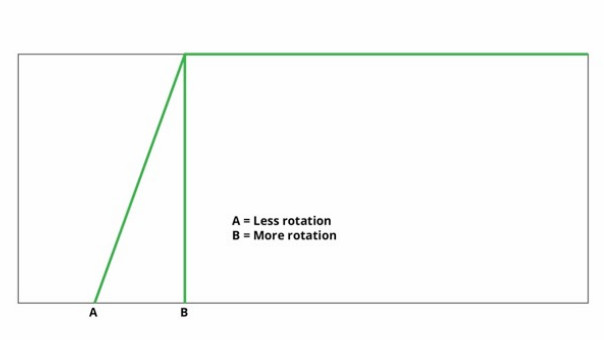
This means we can adjust the speed of that steeper (sometimes vertical) line of throttle application during the initial application, which is rarely discussed. We can also change the percentage of that first application before it starts moving up more slowly (modulation).

Initial application, then modulation.

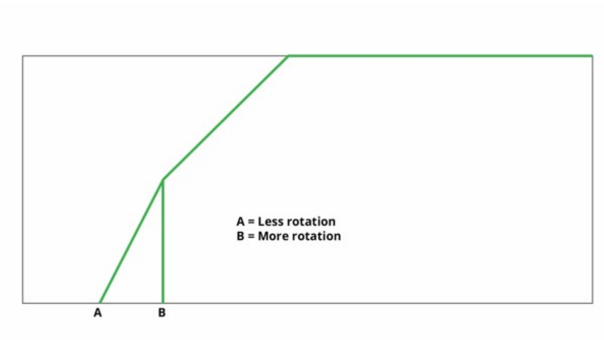
Have this idea very clear in your head and analyze your telemetry to identify how you are doing it.

Let’s use three examples: low horsepower, medium horsepower, and high horsepower engines.

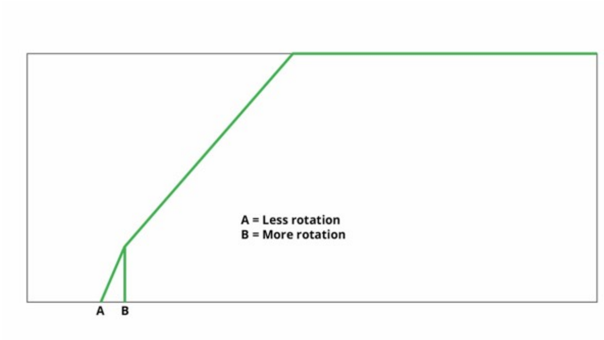
Low horsepower:



Medium horsepower:



High horsepower:



Remember to experiment at different speeds for the initial application, and experiment with different percentages of modulation. This can be tricky to master, as you need to train your right foot to quickly reach specific percentages of throttle.

25

THROTTLE APPLICATION VS STEERING ANGLE

Just like the string theory, where you inversely relate the steering angle to the braking pressure, we can analyze the relation between accelerating out of the corner and how we unwind the steering wheel. After analyzing thousands of students' steering techniques, I've come to a few conclusions and tips to help you maximize exit grip, speed, and safety.

Think about what stages of a corner are safer to force rotation and maximize grip usage. You should get more rotation around the lowest speed point of the corner, and the rotation should decrease as the speed increases towards the late exit phase. Because of this, it is important to keep the steering busy as we get back on power and hustle the car on exit.

One of the most common mistakes regarding steering versus throttle on corner exit is starting to unwind the steering *before* getting back on power.

My view on "hustling the car" is strongly related to getting as much rotation as possible to maximize lateral grip. If you are hesitant about getting back on power because you are afraid of losing the rear and you end up unwinding the steering precariously, you'll lose a few degrees of rotation on the early exit phase. It will then be necessary to compensate for that amount of rotation later (and might be dangerous).

The fear of oversteering on power due to too much steering input can be solved with a simple exercise of inducing understeer on corner exit, discussed a few chapters ago:

1. When applying the throttle, reach a lower initial percentage of acceleration to induce understeer on purpose. This way, you'll safely feel the rotation limit through understeer.
2. Start progressively applying a bigger initial percentage of throttle input until you start feeling a small amount of oversteer.

These two steps will give you the ability to find the limit while being confident that you are on the limit of the front tires through the steering angle.

To recap:

> NEVER unwind the steering angle before accelerating.
>
> ALWAYS unwind the steering angle after accelerating.

When I say after, I mean *a fraction of a second* after. As you start feeling the car on the limit and requesting less steering angle due to the now controlled oversteer, you are able to induce rotation through your precise throttle application.

26

THROTTLE APPLICATION IN FRONT-WHEEL DRIVE CARS

Most racecars are rear-wheel drive. This is because when accelerating, the weight is shifted backwards, adding grip to the rear tires, so accelerating with those loaded tires will be much more efficient. But some racecars are still FWD, so we need to know how to deal with them.

Adding power in a FWD car will cause understeer. This happens because the front tires are unloaded at the same time they are stressed. This means the tires have *less* grip precisely when we need it the most.

Every time you accelerate out of a corner in a front-wheel drive car, weight will be transferred to the rear tires, adding grip to the rear while we're asking for the front tires to pull the car forwards and still turn. This means the front tires get easily over-stressed and break loose, causing the car to plow forwards.

The best way to visualize a FWD car on power is to imagine a rope pulling the front of the car forwards. This is the reason it is impossible to generate a power slide in these types of cars.

To compensate for this behavior, FWD cars are set up to be more oversteery off throttle, so you can get more rotation on entry since we know the car will struggle to rotate on exit.

When accelerating in a FWD car, make sure you don't abuse the steering angle, as this will prevent the car from gaining speed and make the understeer even worse. Because the torque is on the front tires, pointing them towards the inside will change the vector of acceleration accordingly, so steer the least amount possible on exit to get a better exit speed.

27

PLATFORM – THE IDEA OF UNITY

When learning what understeer and oversteer are, we tend to split the car into two halves: the front and the rear. We also tend to think that the car can only oversteer or understeer at a given moment. But this is not true. The car can do both at the same time. The challenge is to maintain a perfect state where all four tires are sliding a little (micro-oversteer and micro-understeer – just on top of the ideal slip angle) throughout the entire corner.

That's where thinking about the car as a single body can help a lot. When you think about the chassis slipping or sliding through the racing line, the front and rear tires will work *together* to maintain this sliding state.

Imagine that you are driving a go-kart. The fastest way around the corner is achieved by having the entire chassis sliding at an obvious angle and maintaining that angle through the entire corner with some slight countersteer. At that point, all four tires should be closest to the optimal slip angle.

What we forget is that cars work the same way. The only difference is that the slip angle is so small compared to karts that we don't notice it as easily. If you look closely at the fastest drivers, you'll find the entire chassis sliding around the corners, instead of one car just going "on rails" through understeer, for example.

Try to imagine a "**platform slip angle**," rather than a separate slip angle for the front and rear. This will make getting the car to the limit twice as easy since you won’t need to think about the rears and fronts on their own. Instead, adjust the steering and pedals in relation to the entire chassis’ rotation.

Some cars will accept higher amounts of slip angle, while others will require a much smaller slip angle value before getting into scrubbing territory.

28

SMOOTH IS FAST? INPUT SPEED VS CORRECTION SPEED

Good racecar drivers know when to make quick changes in inputs, like steering or braking, and when to make them more slowly. Even in ideal situations, there are places where the inputs will be much quicker than others, like turning the steering more quickly when there's no braking involved (versus turning in progressively when releasing the brakes).

In situations where the ideal inputs should be slower, but a problem shows up (like oversteer), the corrections can be quicker if the driver knows what they are doing. Correcting an oversteer through steering is a good example, as we discussed in previous chapters. If you correct for too long though, the car will slingshot wide and lose the line, or, in extreme cases, even spin towards the outside of the corner. In that case, the correction should be made fast, and as soon as the car regains grip, the steering input should immediately go back to where it was supposed to be before the oversteer started.

Watch some onboards of quick drivers and notice how their corrections happen in a much shorter timeframe, preventing the car from losing the line. Then compare their corrections to amateur drivers who make slow corrections that can be dangerous and cause a spin or a crash.

The point of this chapter is to be smooth when it's ideal, but to make corrections as quickly as possible to regain control of the car without going off line too much.

29

HESITATION

A good racing driver spends the most time possible at the edge of traction, from early entry to late exit. This edge is expressed through micro-sliding, oversteer, and understeer, where the car is just about to refuse your inputs. When we go substantially over these limits, we can totally lose control and go off track or crash. Finding these limits can be daunting as the stakes are very high, especially in real life. Because of that, it takes courage and precision to reach these limits in a safe manner. In the end, staying right at the edge of grip is the way to faster lap times. So, we can't really run away from it.

In this chapter I'm going to give you tips on how to deal with hesitation and maximize your learning efficiency. I say learning efficiency because (and this is important!) if you are not at the limit of grip, you are not only losing time, but you are also not *learning*. I'm a fierce believer that if you spend more time over the limit rather than under the limit, you'll develop skills more quickly to manage the car in these states. If you are practicing car handling skills in the simulator, for example, spending time driving under the limit is going to be less productive than spending time overdriving the car.

We have discussed how grip is strongly related to how much rotation we try to extract from the racecar. In this chapter we'll mostly examine hesitation in the form of being afraid to keep the car turning more and more, maximizing lateral grip.

Let me tell you a story of two racing students, how their driving was related to hesitation, and how they overcame it.

Student A was an ultra-consistent driver who stayed very close to the limit at all times. He could maintain his lap times within the same 2 or 3 tenths with no issues, for dozens of laps. His driving looked impeccable. The racing line looked ideal, his braking and steering traces looked smooth, but he was always around one second slower than the ideal lap times.

The biggest problem with Student A was that every time he tried to go faster to chase the last second he was missing, he would get into a small slide and lose his flow. The sliding would get into his head, and he would take a long time to get back to turning the car as much as possible. Note that the time frame discussed here is happening in the *same corner*. So, we're talking about losing the car and being afraid of pushing it again in the same few fractions of a second that part of the corner would take.

Being under the limit after a slide due to hesitation is common for drivers like Student A. Let's call this **post-slide hesitation**. The longer the post-slide hesitation, the less time Student A spent on the limit, and the later he was able to accelerate out of the corner.

Student B had a much more aggressive driving style. She overdrove the car consistently, and even went off track or crashed from time to time. She tried to brake later, oversteered on corner entry, and due to having so much track time with this aggressive approach, she developed a way to manage the slides and keep the car on track. She quickly caught the rear and immediately came back to forcing the car mid-corner, somehow staying on track and aggressively getting out of the corner. Although her driving looked sloppy and full of mistakes, she was also around one second slower than the ideal lap times.

Student B was so used to always sliding the car around the track that she became unbothered with small slides, as she quickly caught oversteer and stayed focused on getting the maximum lateral grip possible. This means the speed of corrections from Student B allowed her to quickly go back to using the grip to rotate the car as much as possible, allowing her to accelerate earlier out of the corner.

How can Student A and Student B find the respective solutions for their driving plateaus?

Student A needed to gain confidence in being over the limit and making corrections without disrupting his craving for lateral grip. He needed to focus on maintaining peak rotation and get used to making these corrections quickly and immediately getting back to his plan. To help with that, we can determine specific stages of the corner in which to force the car more – places where a big slide would be easily corrected with a lower risk of going off track and crashing. This would allow Student A to get used to the feeling of making corrections, to the point that he would start making these corrections more naturally. The best places to force more rotation and work on becoming comfortable with oversteer are the *lowest speed corners on a track*. Forcing the car in a hairpin, for example, allows you to stay calm and pay attention to what is happening to the car.

Fear inhibits learning.

By focusing on inducing oversteer in corners where the consequences of a spin are smaller, we can remove fear from the equation. This way, Student A will be able to work on his post-slide hesitation and will get a grasp on how it feels to be *over the limit*. The next step is to get used to dealing with smaller amounts of oversteer, up to the point where he's able to spend more and more time on top of that sharp edge of micro-oversteer.

Student B is part of a very common group of drivers that share a common habit: to go faster, you should brake later. But it's not that simple. Remember that going faster is about being on the lateral grip during the *entire* corner, getting as much rotation as possible without losing the rear, and accelerating earlier. Since Student B is already used to making quick corrections and maintaining lateral grip at an optimal level, her solution was much simpler: to focus on maximizing grip usage on late entry and early exit, rather than early entry. Drivers who tend to brake too late struggle with maintaining rotation at the same level, which hurts their racing line precision. By braking a tiny bit earlier, she'll be able to unlock much better control of the car. In other words, Student B will shift her focus to force the car towards the lower speeds of a corner rather than corner entry, where the speeds are higher.

The solution for Student B will be much easier to internalize. She'll quickly find time, whereas Student A will have to work on his solution for a much longer time. This is because Student B had not developed much post-slide hesitation, allowing her to spend more time on the limit and learning a more precise car handling technique.

Somehow, there is a common thread between the solutions of Student A and Student B. It is the fact that they should both prioritize forcing the car more towards the center of the corner before starting to force the car more on corner entry. This is already well discussed in the previous chapters, but it's a nice reminder of what to do regardless of your current level of racing technique – especially if you are learning a new car/track combo.

There is really no point in hesitating while practicing on the simulator. There are no negative consequences – you can reset at any time. It is a great tool to try overdriving the car and working on your post-slide hesitation. The more you spin in the simulator, the less you'll spin in real life.

If You Can Cause It, You Can Prevent It

Another super effective way to deal with post-slide hesitation is to not only be unafraid of making mistakes, but to actively try to cause them during practice. Trying to cause a problem will familiarize the feeling of inducing them so that when they happen by mistake, you'll quickly know what caused the problem.

One of the most effective ways to solve the fear of spinning on corner entry, for example, for many students I've worked with, was to ask them to spin the car on purpose (in the simulator, of course). What's funny about this is that they would fail to spin the car. They would use different inputs when trying to spin than the inputs they used when they spin on accident. The most common attempted method to spin on purpose is to turn the steering very quickly. Doing this is actually the *opposite* of what they were doing before, when they spun on accident. And, of course, when trying to steer very quickly, they would just get into instant understeer. After a while of trying to actively spin the car, they would finally understand the tools necessary to induce oversteer. Then, when they were driving normally again and they would spin, they would finally understand what they did that caused it.

Here are a few examples of issues that you can induce to learn how to deal with them:

- Understeer
- Oversteer (and spinning)
- Front tire locking
- Rear tire locking
- Throttle understeer
- Throttle oversteer

Inducing mistakes is incredibly effective, as learning the techniques to correct them will allow you to be on top of every driving issue you might run into when trying to find the limit.

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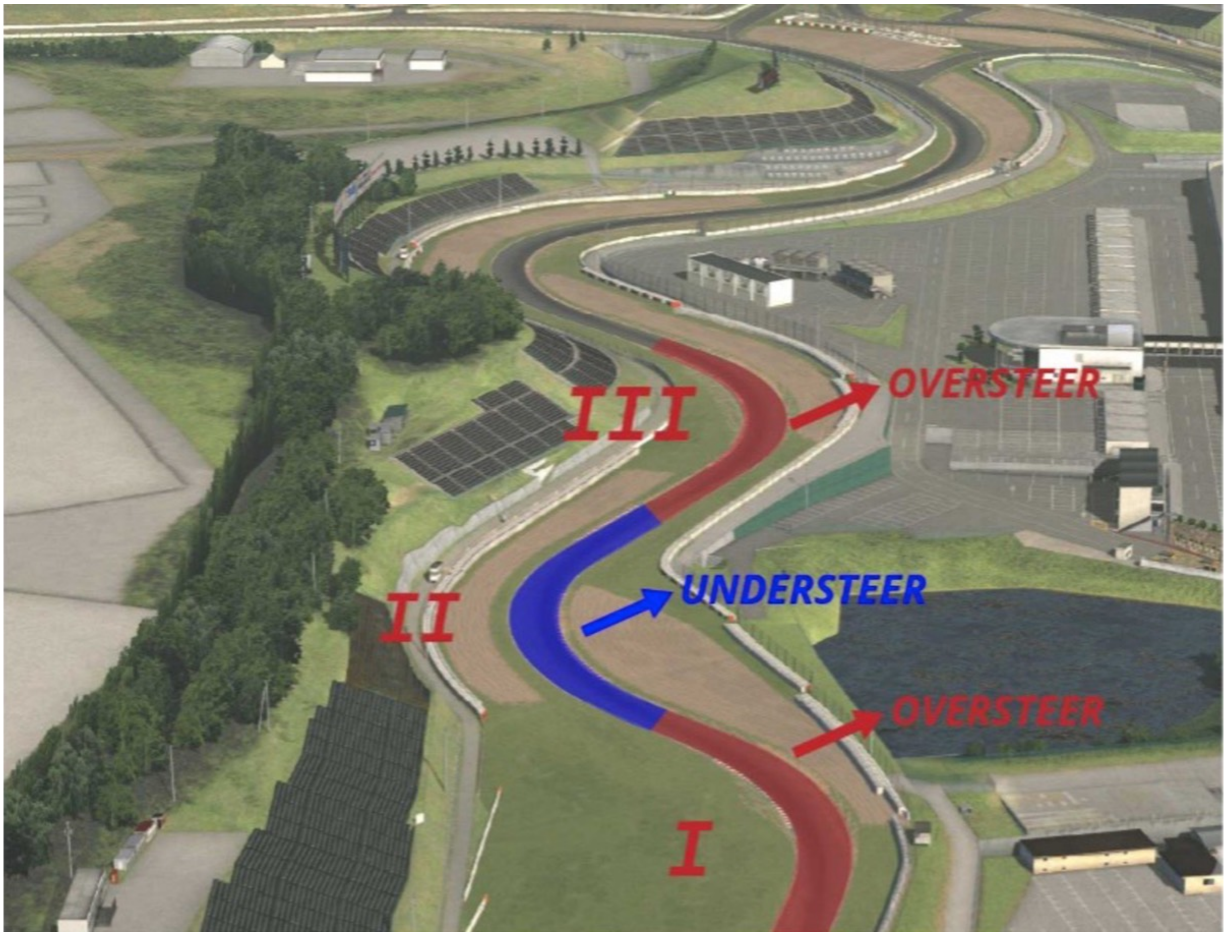
PERCEIVING OVERSTEER AND UNDERSTEER – CAR HANDLING'S REFRESH RATE

As drivers, we must train our senses to become more connected with the car. The more we feel, the more we can act. In the beginning of our technique development, we might be able to identify when the car oversteers or understeers at a given corner, but we can generally only identify one state. As we progress, we become able to identify oversteer and understeer distinctly at each point of a corner.

Imagine that a racing student learns to feel oversteer and understeer for the first time.

At this point, let's say they're able to identify one state per corner:

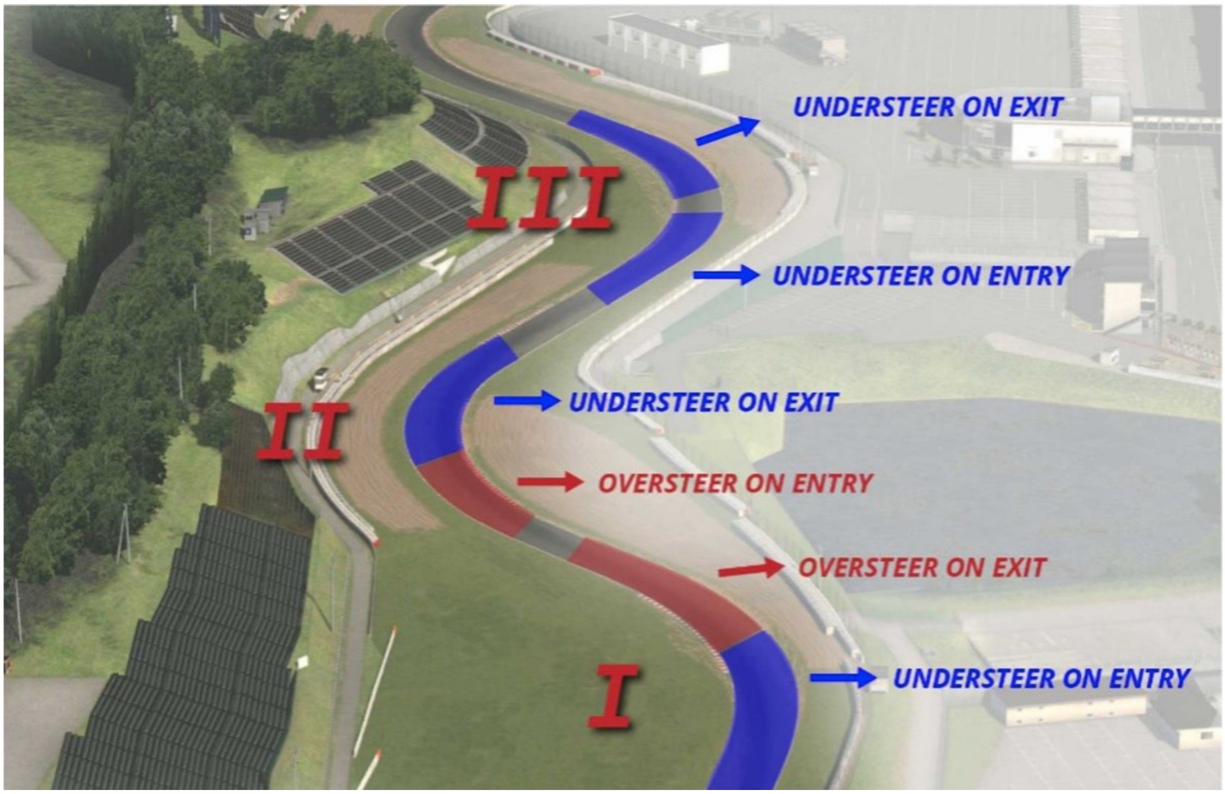
- Turn 1 Oversteer
- Turn 2 Understeer
- Turn 3 Oversteer



After becoming advanced and more comfortable with their driving technique, they start noticing that sometimes the car understeers on entry but then oversteers on exit. This is commonly called **understeer to snap oversteer**, where the driver tries to gain rotation after failing to rotate the car on entry, causing oversteer on exit.

We can then say that the driver is now able to identify two states per corner:

- Turn 1 > Understeer on entry + oversteer on exit
- Turn 2 Oversteer on entry + understeer on exit
- Turn 3 Understeer on entry + understeer on exit

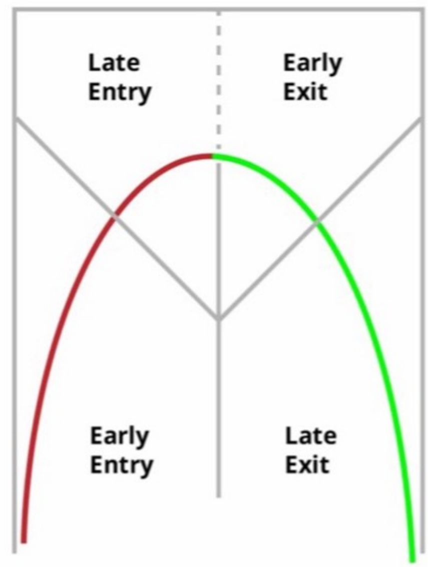


This is where most drivers stop being able to identify anything further, getting stuck at being able to identify only two different states per corner.

Just thinking that more states might be possible at any given corner may be the way out of this plateau. Try thinking about dividing the corner into four stages:

- Early Entry
- Late Entry
- Early Exit
- Late Exit

A good way to develop this sensitivity is to deliberately induce understeer and oversteer at the same corner entry or corner exit. It's possible to shift weight back and forth to make the car rotate more or rotate less, and it's easier to feel it happening when you are doing it on purpose.



Remember that the car can oversteer *and* understeer at the same time (drifting or sliding), which means you are just going too fast if you are doing it and still missing the apex.

Fast drivers can sense and induce these states many times with quick reactions. I call this **car handling's refresh rate**, which is the number of states a driver can identify per corner. Beginners have (as an example), a refresh rate of one state per corner. Intermediate drivers can sense an average of two states per corner, and highly experienced drivers can have a refresh rate of four or more states per corner.

The best example of many states being handled by fast drivers is racing in the wet. The car shifts quickly between understeer and oversteer (and both at the same time, going sideways), and yet fast drivers are able to make several corrections while trying to keep the car on the best line possible.

That doesn't mean that their reaction times are simply better. Repetition brings experience and predictability, so many of those states become predictable and the driver is ready to correct some of them before they even happen (imagine being ready for a bump or curb hit). Also, corrections become automated (muscle memory), so they just happen before we're even aware of them, when properly trained.

Muscle memory development also goes for inducing understeer and oversteer. We can actively practice inducing these states, but after some time, the trigger (for example, "if oversteer, induce understeer") becomes natural in our driving and we don't have to think about it too much.

Let's recap the four pillars of racing technique:

1. Feeling understeer
2. Feeling oversteer
3. Inducing understeer
4. Inducing oversteer

Lap times start improving when you minimize the time necessary to process these skills in your brain. We learn to make big corrections and big inputs to learn the idea, then they start becoming more polished, efficient, and quick. Smaller corrections will increase the amount of time we'll spend on the limit.

Active countersteer is an example of a correction that is most likely bigger than necessary, since excessive countersteer may decrease the effectiveness of the front tires, decreasing grip usage by 50% at those tiny moments of correction. Actively steering outwards tends to be a longer input than just allowing the steering wheel to make natural corrections (passive countersteer), which in contrast can happen much more quickly and more repeatedly, decreasing inefficiencies.

Since active countersteer is a human action, it will take much longer to happen. Passive countersteer can happen several times in the same amount of time a single active countersteer happens. So, although the driver can make several corrections in a single corner through passive countersteer, the number of corrections perceived by the driver will most likely be lower than the actual number of corrections. Using the right techniques, the driver will make corrections to micro-oversteering moments without even noticing it.

“Fishing for grip” is a common way to describe a careful but agile steering input on corner entry, especially in oversteery cars. The driver turns a little bit to find the oversteer and tries to manage the fronts, almost in an on-off motion, to keep the rears at a healthy limit, and keeps slowly adding steering, consistently feeling the oversteer generated as they get deep into the corner, every fraction of a second.

The driver would then: turn-in feel slight oversteer relax hands (less force) repeat.

Of course, this technique must not be overused, as it’s also a potential cause of inefficiencies.

For this technique, I recommend that you try to add these little forces only towards the inside, avoiding active countersteering. Any active countersteering while fishing for grip will decrease efficiency. Remember that to have less excessive oversteer (and therefore less need of active countersteer), utilize the means to induce understeer (downshifting, brake release for weight transfer, and maintenance throttle in extreme cases) at the right time. Using these methods to prevent oversteer will always be much more efficient.

Ask yourself what your own refresh rate is and try doing some laps with that in mind.

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ROTATION TENDENCIES

I mentioned in the previous chapter that we're not always *consciously* reacting to every little thing the car does. More than that, I'd say that in a race, during the flow state, we shouldn't even be thinking about it. The moment to actively think about everything is during practice. A good driver will let as much information as possible about the behavior of the car sink in and then experiment with ways to find time. One powerful way to find the limit and be consistent is to understand the patterns of behavior of each specific car.

Corner Entry

Imagine that a driver tests a new car and says: "The car is oversteery on entry but then pushes mid-corner before throttle."

This means that the car tends to oversteer on early entry but then tends to understeer on late entry.

This behavior may be a pattern in this specific car. We can say, then, that the car tends to oversteer on turn-in but doesn't want to turn towards the minimum speed.

Now that we've identified the rotation tendency of that particular car on corner entry, we can then predict that it will behave in a similar way in most corners. This minimizes the amount of brain processing needed to drive the car on its limit. We can then be more careful with the steering on initial turn-in and try to induce more rotation mid-corner to compensate for the car's behavior.

The driver should adapt their driving style to each car, depending on whether the setup of the car might compensate for its behavior. Some tendencies may be related to the setup of the car, but others might be how the car behaves because of its construction.

Cars with an open differential, for example, tend to rotate a lot more while decelerating, so the turn-in should be more delicate, and the driver must be ready to oversteer and make some corrections with brake release (and in some more extreme cases, maintenance throttle, where the driver accelerates a bit to bring even more weight and grip to the rear tires on corner entry).

Engine braking can impact the rotation tendency of the car on entry. For example, with an aggressive downshift to second gear into a corner, the car will have *high* RPM on turn-in (where the engine braking is making the car rotate more) and the RPM will progressively decrease as the speed decreases. In this case, the car tends to rotate more on turn-in and may tend to understeer mid-corner. Modern Formula 1 cars can adjust the effect of engine braking at different stages of the corner.

It's more common for cars to oversteer on initial turn-in and progressively understeer towards the minimum speed, especially because of the effects of engine braking. Cases of understeer on turn-in and more rotation mid-corner are rarer, but may still be possible, depending on the car and its setup.

Corner Exit

First, remember that, ideally, the rotation of the car is highest at the minimum speed, decreasing as the car accelerates. Because of that, trying to increase rotation on late exit is more dangerous.

The understeer to snap oversteer happens when not enough rotation is done at the lowest speeds, sending the car into a bad and wide line towards late exit, forcing the driver to generate too much rotation when speeds are high.

This possibly causes a spin or sends the back of the car onto the exit grass or into the wall.

The root cause of the understeer on early exit can be hesitation from the driver when applying initial throttle. The driver squeezes the throttle pedal too slowly, shifting some weight to the rear tires without adding enough stress, causing understeer.

Throttle understeer happens when the amount of power applied is too low or done too slowly under the traction limit that the power doesn't make the rears stressed enough to keep rotating the car.

The solution to this situation is achieved when the driver "kicks" the throttle a little more quickly, getting the throttle percentage to the traction limit more quickly. This will add more stress to the rear tires, preventing them from killing the rotation on early exit and maintaining the car on the right line. Some cars might even *need* an aggressive punch to the throttle to keep rotating, which might be trickier to try since they may quickly switch to oversteer and spin.

Another root cause of the understeer might be car setup. Let's say the driver identified the understeer but fails to solve it with a more aggressive throttle application. In this situation, the car might be sending too much grip to the rears, and the stress from the throttle is not enough to compensate properly. In this situation, a change in setup would be necessary to fix the car's behavior. This generally happens in low-powered cars since wheel spin would cause oversteer in almost all cases.

Feel the car. Find its tendencies. Being able to describe its behavior to other drivers and engineers shows how good of a driver you are and how aware you are of the situation.

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HANDLING PROBLEMS AND SOLUTIONS

For the final chapter of this book, I wanted to discuss some common problems I have encountered while coaching over two thousand students. Use this book as a reference when practicing. Remember that this book is long and complex, so just reading it once and then forgetting about it might not be the best idea. Always come back and try to find techniques or details that you haven't applied on track yet.

PROBLEM

I can't hit the apex. While forcing the car to get to the apex, I lose the car or understeer wide.

CAUSE AND SOLUTION

Too much speed. you are braking too late, and the car doesn't have the traction to turn into the corner and hit the apex. Whenever you oversteer and still lose the apex, you are carrying too much speed. In some rare cases, you may be generating way too much rotation too quickly on turn-in, either by trail braking too hard and turning in too quickly (especially in karts), or by using too much engine braking and trail braking too hard. Try to spread the rotation through the corner instead of concentrating a lot of it on turn-in. If this still doesn't work, brake earlier.

Turning in too late. You might be expecting the car to already give you too much rotation on entry. Remember that your rotation should increase as you slow down, so you must turn in a little earlier and more progressively, creating a more V-shaped line.

PROBLEM

I keep over slowing the car into the corner.

CAUSE AND SOLUTION

you are probably turning in too late, keeping the brakes pressed too hard for too long. you are most likely building an arc that fits on a tighter track than the one you have available. Make sure you are using the entirety of the track and try turning in earlier, which will force you to start releasing the brakes sooner and carrying more speed into the corner. Trail braking is necessary to keep the rotation going while making this adjustment. With the extra speed mid-corner, your exits will also feel different, so take some time to adjust to that.

PROBLEM

I keep losing the rear on corner entry.

CAUSE AND SOLUTION

Remember the three tools for rotation: steering, trail braking, and engine braking. When we start oversteering on entry, we tend to try using less steering, but that will probably not be the solution. Remember that if you induce understeer by trail braking less and downshifting later, you can understeer such that no matter how much you turn, the car will not lose the rear. With that in mind, try to release the brakes a little quicker or downshift slower to prevent rear locking or micro-locking and move the balance towards understeer. If you are alternating between oversteer and understeer while trying this, that means you are just too fast.

PROBLEM

I keep understeering on corner entry.

CAUSE AND SOLUTION

You might be either braking *too much* or *too little*. There is a sweet spot in trail braking where the grip in the front is higher because of the weight transferred to them, but not enough braking that you engage the ABS on the front tires or lock them up. Find the perfect amount of braking (remember that it's a moving target, it decreases as rotation increases) that increases rotation, rather than decreasing it.

You may be turning the steering too fast or too much. Remember that if you turn too much, your front tires will exceed the optimal slip angle of the tire, causing scrub, wearing the tire, and decreasing grip. You can ask the fronts to turn the car until a certain point, after which you'll be losing traction and gaining less rotation. Remember the rule: if you are braking, you turn in slowly. If you are not braking, you can turn in more quickly.

If it's a rear-wheel drive car, try downshifting a little quicker. The engine braking might be stressing the rear tires a little more and carrying that extra stress into the corner (with higher RPM) might help the car rotate.

PROBLEM

I keep understeering on power.

CAUSE AND SOLUTION

You might be squeezing the throttle too gently. The throttle has two functions. It makes the tires spin more quickly, but that shifts some weight to the rear tires, giving them grip. At low percentages of throttle, the amount of grip the rears gain beats the amount of stress from them wanting to spin more quickly, causing the rear to have unnecessary extra grip. At high percentages of throttle, the amount of stress from them wanting to spin quicker beats the amount of grip the rear tires receive from the weight transfer, causing the car to lose the rear. There is a perfect balance point where you get the ideal amount of wheel stress versus grip from weight transfer, which makes the car maintain a controllable rotation, or micro-oversteer. This perfect balance point is a moving target and depends on the speed of the car and the available grip. At each point, there will be a specific ideal throttle percentage. If you accelerate to that point right away, you'll get a nice rotation. If you smash the throttle over that point, you'll get oversteer. If you squeeze the throttle too slowly below that point, you'll get understeer.

you are not getting enough rotation on entry, and you need to compensate for it with even more rotation on exit. Remember that cars are much more effective while decelerating than while accelerating. Because of this, a higher portion of the rotation must be done on entry, such as 55% on entry and 45% on exit. If you don't make the car rotate enough on entry, it won't be able to cope with the throttle plus the excessive rotation it has to do on exit.

PROBLEM

I keep oversteering on power.

CAUSE AND SOLUTION

you are just going over that perfect sweet spot I mentioned in the last problem. Squeeze the throttle just as fast, but to a lower percentage initially.

If the car still can't make the corner, going wide on exit, and you are just alternating between understeer and oversteer, you are not getting enough rotation on entry, just like the second point of the last problem.

PROBLEM

Under braking, the car is unpredictable, sometimes understeering too much and sometimes oversteering too much in a snap.

CAUSE AND SOLUTION

you are gripping the steering wheel too hard. Relax your hands in proportion to how hard you are braking. Brake hard, relax more. Brake less, grip the steering a bit more. Never grip the steering too hard – only enough to move the steering against its own resistance or feedback.

you are turning in too late. Try turning in earlier and slightly slower to see if the car is capable of dealing with a gentler radius initially without breaking loose or understeering.

PROBLEM

I'm new and my main struggle seems to be resisting the temptation to overdrive the car, making little errors, and chewing through tires – my brain knows I need to be smooth but come race time it's so easy to get caught up in trying too hard when chasing or under pressure. What should I do?

CAUSE AND SOLUTION

Overdriving the car generally comes from just braking too late. But you can test the limits in other ways:

Trying to get more rotation as soon as you turn-in, pointing the car more and being able to accelerate earlier.

Trying to release the brakes a little quicker but keeping some brake pressure to keep the car rotating.

Trying to smash the throttle a little more aggressively and in different ways (trial and error).

Do all of this while keeping the braking point the exact same.

FINAL THOUGHTS

Remember that this book encompasses techniques that will be developed over many years of your career. you are not supposed to master everything in a month, but rather over many stages of your career, bit by bit, as you chase the last tenths, then hundredths. You might have noticed that I didn't mention or define some techniques, such as traction circle, slip angle, driving in the rain, heel-and-toe, and many other concepts and techniques that are widely available online. My intention in this book was to explore unique concepts that I believe you won't find anywhere else.

This is the first book of a trilogy that I plan to release over the next few years. This first volume was solely about car handling. Volumes 2 and 3 will discuss racecraft (battling for position, attacking and defending strategies, and much more involving actual racing, not only hot lapping) and car setup.

To continue improving your technique, use BOOK30 and get 30% off *The Motor Racing Checklist*. This course contains over 60 video lessons on all of the techniques described in this book, along with bonus exercises and practice sessions with professional drivers. Join on my website, www.suellioalmeida.com.

You can also watch all my free YouTube racing technique content at youtube.com/suellioalmeida

Have any questions? Join our discord community and discuss anything from the book or the online course with this QR code:

I hope this helps get you closer to perfecting your driving technique. Remember to always, *always* have fun while doing it. Having fun is the main reason we do this.