Round The Ring

Driving The Nordschleife On A Simulator

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by Amen Zwa, Esq.

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PREFACE

"It's like, if you walk up behind a vicious dog, if you talk to the dog on the way up, it wouldn't be caught by surprise, and it wouldn't do something unpredictable."

— Sir Jackie Stewart (F1 triple champion on car behaviour, Top Gear)

Auto racing is exhilarating, but it is a costly pursuit. And as Sir Jackie said, a race car can sometimes behave like a "vicious dog" with a deadly bite. Thanks to a few race engineers and software developers, however, we can now experience the thrill of driving a race car at its limits, without leaving the comfort of our living rooms, and more importantly without risking life, limb, or lolly.

Although PC-based racing simulators have been around since the mid-1980s, it was Grand Prix Legends that set the standard of excellence in 1998, in terms of realism, appearance, and performance. A confluence of technical developments occurred in the mid-1990s that transformed a lowly racing game into a realistic racing simulator: fast CPUs, capable 3D GPUs, decent operating system, racing wheel with foot pedals, and realistic vehicular physics models. Through the years, racing simulators have made great strides in capabilities, each generation more capable than the last. Of late, there has been a spate of topping simulators. Even the humble gaming console now has a few titles that might persuade a parsimonious pavement pounder to part with his penny.

I share with you in this book my enthusiasm for racing simulators, and especially my admiration for the Nürburgring Nordschleife—The Ring. Note that this book is not about earning the most gaming points, defeating the on-line opponents through unfair means, or learning how to drag and drift; the emphasis is on traditional road racing.

Being that this is a book about simulator racing, I had to choose a simulator and a car about which to write. For a variety of reasons, I chose Need for Speed Shift 2: Unleashed (S2U) and BMW E30 M3 Sport Evolution. But even if you own a different simulator or fancy a different car, there is nothing to dissuade you from learning about racing components, car set-up, driving techniques, and other generally applicable concepts that I present herein.

I wrote this book in what little spare time I have, so that I may share with you the thrills of driving round The Ring and the joy of driving on the simulators in general. If my book increases the number of simulator fanciers, I would consider my mission accomplished, because I believe that a larger consumer base will encourage more software manufacturers to create finer simulators in the future.

In addition to the Nordschleife, I provide a track guide for the Nürburgring Formula 1 track. That means you can now learn to drive four configurations of the Nürburgring: the 5.1 km Grand-Prix-Strecke F1 circuit, 19.1 km Touristenfahrten, the 20.8 km Nordschleife, and the 25.4 km Gesamtstrecke. Although S2U does not model the Touristenfahrten and the Gesamtstrecke configurations, other simulators do. So, the knowledge of different configurations will be of use to you.

With this book as a vector, I hope to transmit a virulent strain of racing bug to you. May the gods of speed save your soul. I bid you good luck, and hope that you will learn to love simulator racing and The Ring. Cheers!

— Amen Zwa, Esq.

CHAPTER ONE — INTRODUCTION

overview

The Nürburgring comprises many different track configurations, but the 20.832 km Nordschleife variety is the one that grips everyone's imagination. It is the configuration upon which the major car manufacturers strive to pip one another with progressively shorter lap times. It is also the focus of this book. I devote a good portion of this book to driving this temperamental, serpentine track coiled into the scenic hills and dales of the Eifel Mountains in western Germany. I describe in detail all the corners, the reference points around them, and the racing lines through them. I also show how the corners look from the cockpit and from the satellite. Although surface irregularities, trackside objects, and other minutiae are specific to S2U, the more general descriptions of corner layouts and racing lines can still guide you as you pound round the track on some other simulator you prefer, rFactor 2, Assetto Corsa, iRacing, Gran Turismo, and the like.

This book is for enthusiasts to use on simulators. Trackside references objects, surface irregularities, and other details mentioned here do not match the real track. In real life, this track is a one-way toll road, which, except on race days, is open to the public. A complete novice with just a few Euros to his name can seek glory, at least for a few minutes, by driving a lap round the Nürburgring Nordschleife Touristenfahrten in a hired sports car. If you do intend to drive in a spirited manner on the real track, take instructions from the professionals; do not rely solely on the information provided herein. Or else, you may join the ranks of the Dead Ringers.

Indeed, I have never driven on the real Nordschleife, so I am no Ring Specialist even by the most generous of measures. But I have been driving the virtual track regularly and frequently since 1998, on nearly every racing simulator that models it. Yet, my enthusiasm for the track has not dimmed with the passing years. The Ring is like the flu: obsession with it spreads easily and quickly, and once it is in you, it is difficult to be rid of.

roadmap

But this book is much more than just about the Nordschleife. It is a comprehensive introduction to race driving with the simulated Nordschleife as the training ground. It is also a tutorial on race car dynamics, race car components, and race car set-up.

I present in *The Simulator* chapter some of my favourite simulators, and choose one for use throughout this book. I also explain how to configure the chosen simulator, Need for Speed Shift 2: Unleashed (S2U), in such a way as to reproduce the most realistic look and feel for race driving.

Next, in *The Car* chapter, I present a few different cars in S2U that are suitable for use when learning to race, and choose the BMW E30 M3 Sport Evolution race car to be driven on The Ring. Then, I discuss the functions of race car components, describe race car handling characteristics, and explain how to tune the components to make the car suit the driver and the track.

I present the all-important topic of smooth driving in the chapter *Driving Techniques*. When it comes to speed, it pays to be neat. And driving style is inseparable from car set-up. The race car is set up to suit the racer's driving style and the track's characteristics. But there is a limit to how much the car can yield. To some extent, the driver, too, must adapt his style to the characteristics of the car and of the track, in order to extract optimum performance from the driver-car package. Proper driving techniques help the driver wring the highest performance out of the car.

In *Learning The Nordschleife*, I describe the simulated Nürburgring Nordschleife track in detail, every sector, every corner, every bump, and every reference point. And I explain how to take the proper line through each corner. Certain details like the advertising hoardings, flagpoles, and the track surface irregularities are specific to how S2U implements The Ring, but the track configuration and the racing line I describe are sufficiently general to be of use to those who intend to drive on a different simulator.

Finally, in *Learning the Grand-Prix-Strecke*, I cover driving the Nürburgring Grand-Prix-Strecke Formula 1 track. Apart from a few tricky corners, this track is fairly straight forward as racetracks go. But it packs loads of fun, nonetheless. Once you have learnt this track, not only can you partake in a Formula 1 style race, but also in the famed, 24h Rennen Nürburgring endurance variety. Note, though, that S2U does not model the 24h configuration. But several other simulators do.

about the author

I am an erstwhile amateur racer and a long-time race simulator fan. I have been an avid—nay, rabid—flight and race simulator user since the early 1980s. Professionally, I work as a technology consultant. My degrees are in electrical engineering, computer science, and law. My practice focuses on business development, technology licensing, image processing algorithms, and user interface design. And I have been a programmer for over a quarter of a century, and I still write code on a regular basis, mostly in functional programming languages. Indeed, writing is in everything I do: business proposals, legal opinions, patents, contracts, software, design documents, scientific papers, and technical books.

As I am not a professional driver and as I do not build race cars for a living, why should you accept anything I say in this book? The short answer is that you should not. You should question everything everyone says, evaluate the arguments for yourself, and make up your own mind. But I will say this much. I believe that my professional background and personal experiences have equipped me with the skills necessary to explain such intricate topics as vehicular dynamics, car set-up, car handling, driving techniques, psychological factors, and the like, in a way that can be readily understood. Sure, there are many who know these topics better than I, and there are many who drive faster than I. And yes, there are many who write better than I. But they none of them took the time to write an in-depth book about simulator driving. I did, because I enjoy simulator racing, and I like sharing that enjoyment with my fellow simulator fanciers.

My books are self published in various ebook formats. I chose to publish in electronic medium, instead of on paper, because of cost and control. The added benefit of the electronic medium is that I can put in hyperlinks to external information sources, so that my readers could conveniently pursue further the topics that caught their eyes. Publishing exclusively as ebooks does not mean that my readers must invest in ereader devices, however, since all the major ebook sellers have web-based ereaders.

But because my books are self published, I am the researcher, the author, the proofreader, the editor, the typesetter, the illustrator, and the publisher. To add to my struggles, English is not my mother tongue. As such, grammatical, typographical, and other forms of errors may seep in at places. For that, I apologise ahead of time. Drop me a line, if you find an error. I will include in the subsequent edition your correction to every critical error, and an acknowledgement of your contribution will appear in the footnotes.

It is my practice not to create a new book page for a new edition of my books. Instead, I publish the new edition on the original book page. I do this, so that my readers who purchased an older edition of the book could receive the new contents automatically, without having to pay for the new edition. But the downside is that the book page continues to display the original publication date, even though the book may have been updated several times during the intervening years. This tends to turn away potential buyers, who, without reading the book description, assume that the book is too old. It is a judgement call, and I chose to err in favour of those who already purchased my books.

I do not write books like this one to make a living; I make my living by other means, so that I could have the spare time to write such books. And I write not because I believe I have some special knowledge to impart, but because I enjoy sharing with others what little I know. The desire to share is the same drive that compels me to teach programming classes and give negotiation seminars, from time to time. Teaching gives me the opportunity to probe deeper into the subjects and to fill holes in my own understanding thereof. And sharing knowledge and ideas invigorates me. So, there you have it.

“He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me.”

— Thomas Jefferson (1813 letter to Isaac McPherson)

contacting the author

Reading a book, in some ways, is like conversing with the author. Indeed, I consciously chose to write in a conversational style, because I wish to make you feel that you and I are having a one-on-one conversation, a friendly little chat between two equals. But, in truth, this conversation is one-way, so it is not much of a conversation at all. Thanks to social media, however, you and I can have an actual, two-way communication. So, I hope you would reach out to me on social media.

The easiest way to contact me, and the quickest way to get a response from me, is via Twitter (@AmenZwa). Follow me, and I shall follow you back, right away. We can, then, exchange public tweets, or private messages. And call me by my first name, please. For topics of general discussions, feel free to post to my forum Simulator Racing on Amazon, so that all the readers can participate.

I always respond to my readers' cheers and comments, as quickly as my schedule permits. I am always grateful to kind encouragements, for they keep me going. To reasoned critiques, I am just as thankful, because they improve the quality of my writing to the benefit of all readers. When I incorporate readers' critiques into the text, I acknowledge their contributions either in the preface or in the footnotes.

It is my practice not to respond to bald criticisms unsupported by reason, such as "boring," "terrible," and the like. Because they are subjective opinions, I cannot learn from them. And because they are unreasoned assertions, I cannot respond to them with reasoned arguments. But to an author, even such criticisms are more informative than the apathetic silence of his readers.

Lastly, I request that you visit my Amazon author page, and rate this book. Those little stars mean rather a lot to me.

CHAPTER Two — THE SIMULATOR

overview

We must satisfy a few prerequisites, before we can race on a simulator: select the simulator software, set up the simulator hardware, configure the simulator software, select the car, tune the car, and learn the race driving techniques. In this chapter, I first present an overview of a few simulators that I particularly fancy, and then I select one that we will use for the remainder of the book. Note that although I will be relying on one simulator for the specifics like the visual references and track surface conditions, the fundamental concepts I present in this book, such as corner configurations, suspension adjustments, load transfer, tyre slip angle, and the like, are applicable to any simulator, and indeed to real world driving.

There is now a panoply of software titles marketed as driving simulators, but not all of them are worthy of your time and money, because many are mere games, not simulators.

Several of the titles have won the hearts of the simulation enthusiasts (as opposed to gamers) the world over. On the PC, Grand Prix Legends, F1 Challenge, GT Legends, rFactor, rFactor 2, netKar Pro, Assetto Corsa, and Richard Burns Rally are some of my favourites. The primary goal of these simulators is realism. They simulate environmental conditions, track characteristics, plethora of suspension adjustments, fuel status, tyre temperatures, oil temperature, oil pressure, engine temperature, engine mapping, differential mapping, brake bias, and more.

And there are a number of popular titles for the console such as Gran Turismo, Need for Speed, RACE, and DiRT. There is also Project CARS, a crowd-funded simulator. These titles endeavour to strike a balance between the desire for realism and the need for entertainment, thereby accommodating not only the simulation enthusiasts but also the gamers.

I selected for this book the PS3 version of Need for Speed Shift 2: Unleashed (S2U). I did so, because this book is aimed primarily at novice racers who wish to extract the most out of a decent simulator. S2U is plenty good for that purpose. Moreover, PS3's graphics subsystem is capable of generating high frame rates necessary to reproduce the sensation of speed. To extract acceptable simulation frame rates from a PC simulator, one would have to spend a princely sum on the PC, the graphics card, the monitor, the sound card, the speakers, and the like, then spend an inordinate amount of time experimenting with the graphics and the input device settings, as well as sorting out the weird interactions between the operating system device drivers and the simulator software. Configuring a PC-based simulator is a black art wholly unrelated to driving, so I wish not to tackle it in this book. And why not the Xbox, you ask? Because I do not have an Xbox. Regardless, those who drive a simulator on a PC or an Xbox would still benefit from the general information contained herein.

I did seriously consider choosing Gran Turismo 5 (GT5), due to its long-established popularity on the PS3. And it provides a wealth of popular cars and tracks. It also supports dirt and snow tracks for rallying. Importantly, its rain and snow visual and traction effects are almost as good as PC-based simulators. Yet, I find GT5's vehicular dynamics model trailing behind S2U in terms of realism. Cars in GT5 glide through corners in dignified grace like genteel debutants, and the track surface is smooth like a placid lake on a warm summer evening. But that is not the worst of it. The most vexatious thing about GT5 is its imbecilic clutch modelling. If the throttle is not completely lifted when shifting gears, GT5 will prevent the gear from engaging. As such, heel-and-toe downshifting, which I explain later, is utterly superfluous in GT5. These flaws make GT5 unsuitable for pedagogical purposes.

In contrast, S2U is almost as realistic as some of the PC-based simulators, and it does not suffer from GT5's crippling flaws. Still, S2U has its inadequacies. There are no rain, snow, or fog effects. There are no dirt tracks. Its Monaco knockoff track, called The Riviera, is horrid. And the sullen colours are distracting. The on-screen steering wheel lags behind controller input by about a Martian sidereal day. The handbrake cannot be feathered; it is either off or on. Fuel consumption and tyre degradation are not accurately modelled, if at all. And the damage modelling is, well, damaged. It appears to take the energy of the K-T asteroid hit to cause some noticeable damage, and even then the damage is mostly visual. Unless the wheels fell off, it is usually possible to crack on at race pace, even after multiple end-over-end tumbles. Let me stop there with the negatives, before I change my mind on S2U.

But the positives outweigh the negatives. The steering feel could be improved by experimenting with the configuration settings, which I describe below. Engine sound reflection from the walls when passing under a bridge is a nice touch. Dawn, dusk, and night lighting are very good. The haze attenuation effect is exquisite. The helmet view and the head movement modelling in S2U are the best I have seen, even better than the PC simulators. The near-field blurring effect and the bug splatter on the windshield, though gratuitous, do heighten the realistic sensation of driving a race car at speed. And the most important thing for our purposes—the physics model—is adequate. It is comparable to the mid-range PC simulators. These are my reasons for choosing S2U for this book.

I also considered rFactor 2, a popular PC-based simulator. But I decided against it, because I wish to focus sharply on The Ring in this book, instead of having to devote many pages on configuring this complex and sophisticated software. Nevertheless, the experienced PC simulator drivers who are new to The Ring will find use in my descriptions of the corners and the racing lines through them, thus able to extract one of the key benefit from this book—learning to drive the Nordschleife. And of course, a novice who just happened to have invested in a PC-based simulator will additionally benefit from the first part of this book, where I describe the race car behaviour, set-up, and driving techniques. By all means, feel free to use this book with rFactor 2, Assetto Corsa, iRacing, Gran Turismo 6, or any other PC- and console-based simulators. You simply have to glide over the details in my descriptions such as bumps, flags, banners, and the like, because these minutiae differ from one simulator to another.

Those who wish to try out a realistic PC-based simulator should purchase a copy of Assetto Corsa, and read my book *Going Nowhere Fast In Assetto Corsa: Race Driving On A Simulator*. That book also describes The Ring, because Assetto Corsa includes a laser-scanned model of this track. But The Ring track guide in that book is not as detailed as here, because the focus of that book is simulator driving, not just one track.

At least in one respect, the console-based simulators are better for learning the Nordschleife than the PC-based ones: both GT5 and S2U provide sectors, in addition to the whole track. The sectors make it easier for the novice to memorise the track. In contrast, on the classic Grand Prix Legends, the simulator on which I learned to drive the Nordschleife, I had to learn by driving the whole track at a time. So, to learn the last few kilometres of the track, I had to drive all the way round the track first, thus wasting much time.

Lastly, remember that this book is directly aimed at those who wish to drive the simulated Nordschleife, at a race pace without crashing out, in a properly tuned classic race car with neutral handling characteristics. It is not about setting a record time on The Ring. It is not a cheat sheet for earning S2U achievement medals. It is not about drag racing in a high-power car. And it is most certainly not about drifting, that profligate act of sliding the car through a corner at a walking pace, while converting expensive racing rubber into loud noise, noxious smell, and impenetrable smoke, as the lustful crowd cheers for more carnage. In those happy days before cars sprouted inverted wings (and stopped flying), four-wheel drifting was an important driving technique used to carry speed through the corners. Modern winged wonders produce so much downforce that drifting no longer carries the significance it once did. Since our focus here is on driving the wingless, classic race cars, four-wheel drifting is a useful technique to learn. Hence, I discuss this technique in the section on driving techniques.

simulator set-up — hardware

You should install the following devices, in order to enhance the realism of your living room racing simulator:

Purchase the now-discontinued Logitech G25 racing wheel, or the newer G27, if not. Although the G27 is newer and mechanically superior to the G25, I prefer the 60s race car steering wheel look-and-feel of the G25. This force-feedback wheel comes with a six-speed, gated shifter and three pedals. There is also the F1-style, flappy-paddle shifter on the steering column. A wheel with a gated shifter and three pedals is mandatory for learning to drive a classic race car. So, avoid buying a wheel that does not have these bits. The G25 has a grey rotary knob just behind the shift lever. Rotate that knob fully to the right, until its red arrow is in the gated shifter position. No matter what, please do not drive with the PS3 handheld controller.

Although this is an optional piece of equipment, I highly recommend that you purchase the Playseat Evolution with seat slider and gearshift holder. The G25, the Playseat, and the gearshift holder combination shown in the photograph below places your body in a proper race driving posture, which is ideally suited for learning the heel-and-toe downshifting. The placement of the gearshift holder is a matter of personal preference. If you like a right-hand-drive, manual-shift car, like the fabulous Caterham Superlight R500, my absolute favourite, install the shifter on the left, for added realism. And if you prefer a left-hand-drive classic, like the BMW M3 E30 Sport Evolution, place the shifter on the right, as Nature commands. Here are a couple of top tips. Install felt pads under the Playseat rails and sliders, to avoid marring your wood floor. And tidy up the G25's wires by routing them along the Playseat's wheel support column, and by securing them with a few plastic zip ties.

Hook up your PS3 to a 1080p-capable, flat panel TV, using an HDMI cable. The physical size of the TV is less important, as you can adjust the distance to reproduce a desired field of view. But the 1080p resolution is essential for high-quality imagery.

simulator set-up — software

Now, install the simulator software and a few indispensible add-ons as follows:

- Install Need for Speed Shift 2: Unleashed either from the DVD or from the PlayStation Store.
- Purchase on PlayStation Store the S2U Unlock All Cars and Tracks time saver pack, and install it. We want to start driving on the Nordschleife immediately, without having to earn points first to unlock this track.
- Purchase on PlayStation Store the S2U Legends Pack, and install it. We will use one of the classic race cars from this pack. Many classic cars included in this pack are some of the best handling ones in motorsport history, thus providing the most on-track fun.

Then, configure the simulator as follows:

- Start S2U. When G25's wheel begins to rotate from side to side, fully depress and release the three pedals multiple times. S2U can determine the wheel's full range of motion through this automatic calibration process. But you must calibrate the pedals manually, as I stated.
- Create an Autolog account, and sign in.
- From the main screen, enter the Options screen, and perform the settings as I describe below.

gameplay

- **Difficulty**: Hard
- **Handling Mode**: Elite

- **Steering Assist, etc.**: No
  - These artificial aids engender bad driving habits. From the start, drive with the most realistic settings, just as you would in real life.
- **Damage**: Full Damage
  - We need to commit fully to the learning process, so crank on the full damage. Remember though that S2U's damage modelling leaves much to be desired.
- **Best Line**: No
  - Those who depend on the painted racing line fixate on it, instead of on the trackside visual references. When racing, your attention must be on the track ahead and on the opponents, not on what is immediately in front of the car. Although you will not have the artificial racing line as a crutch, you still have the consensus line, that faint, dark streak on the track surface painted by the tyres of countless cars that had driven through the corner.
- **HUD, Show Online IDs**: Off
  - Minimise visual distractions.
- **Display Units**: Metric
  - Imperious drivers may use Imperial. (Relax; I am joking.)

controls

- **Preset Config**: Logitech G25 Racing Wheel
- **Gears**: Manual
- **Automatic Clutch**: No
  - Since we will be learning how to perform heel-and-toe downshifting, we must set the gear and clutch to the most realistic settings.

Adjust Controls—Control Bindings:

- **Handbrake**: R2 button
  - Since neither the G25 nor the G27 has a handbrake lever, we have to assign the function to a readily accessible right thumb button on the steering wheel. Note, though, that S2U's handbrake modelling is useless.
- **Look Back**: L2 button

    - When racing, you will need to maintain a situational awareness of all the opponents around you. S2U's visual field is quite narrow, and many cars have rear view mirrors partially or completely outside the visual field. So, you will need to use the look back button often, and it needs to be readily accessible with your left thumb.
    - Swap the L2 and R2 functions, if you installed the Playseat gearshift holder on the left side (for right-hand-drive cars), so that you can use your left thumb to activate the handbrake. In the real world, the right hand operates the gear shifter and the handbrake lever in left-hand-drive cars, and the left hand does the work in right-hand-drive cars.
    - For other less essential controls, assign the functions to the remaining buttons in a way that is easy for you to remember.

Adjust Controls—Advanced:

- **Force Feedback Strength**: 100%
- **Steering/Throttle/Brake/Clutch Deadzone**: 0%
- **Steering/Throttle/Brake/Clutch Sensitivity**: 50%
- **Speed Sensitivity**: 0%
- **Steering Lock**: 900
- **Invert Gears**: Normal
- **Invert Camera Y Axis**: Normal
    - With these settings, the G25 feels most realistic. The G25 wheel is capable of rotating 900 degrees, lock to lock. Reducing this range will make the steering wheel more sensitive. But I recommend that you retain the full range of the wheel, and instead raise steering sensitivity using the steering lock, when setting up the car.

audio

- **Master, Vehicle, Sound Effects**: Max
    - It is more convenient to control the sound level using the TV's master volume control.
- **Speech, Music**: Off
    - That built-in, disembodied voice does prattle rather a lot. Turn off

both him and the distracting background music. Music and other forms of entertainment do not belong on a racing track.

- **Online Player Mute**: Yes
    - In real life, racers do not talk to their opponents, while they are racing on track.

video

- **Calibration**:
    - This screen walks you through the TV display calibration process, step-by-step. Perform the calibration for best visual effects.
    - Note that the PS3 version of S2U does not allow the user to adjust the video parameters such as field-of-view, anti-aliasing, texture filtering, and the like.
    - Switch to the helmet view by first entering the cockpit, then pressing the Change View button a few times until you see the helmet padding encircling the view. The helmet view offers the most realistic out-of-cockpit view. So, always drive in this view.

CHAPTER THREE — THE CAR

overview

S2U categorises cars into four groups, based on their performance index (PI):

- Group D: PI up to 499
- Group C: PI from 500 to 999
- Group B: PI from 1000 to 1499
- Group A: PI above 1500

Many of the classic sports cars found in the Legends pack, such as Jaguar E-Type, Nissan Fairlady, Alfa Romeo Giulia, etc., are in Group D. All the exotic sports cars and the GT1 race cars are in Group A. And in between, there are loads of interesting cars in Groups C and B.

Before we proceed, let us set the terminology straight. The word "tune" is commonly used to refer to two distinct, but related, activities: (1) swapping in higher quality components, or (2) adjusting the parameters of the installed components. For clarity, we shall use the term "upgrade" to refer to the first sense, and "tune" to mean the second sense. This is also the convention used in S2U's screens and menus.

In this book, we will use as our mount a German classic with a racing pedigree—the brilliant little BMW E30 M3 Sport Evolution from the Legends pack. S2U labels this car "BMW M3 E30." I use the name "BMW E30 M3," because BMW is the manufacturer, E30 is the platform of the car, and M3 is the top model within that platform. Pounding round The Ring in a classic M3; imagine that. From S2U's main screen, enter the **Car Lot** screen and acquire the M3, after ensuring that you have installed the above-mentioned add-on packs, of course.

Read Dr. Gustave Stroes's fabulous web site E30 M3 Performance to learn more about this car. In addition to the M3, you should also try the following cars: Mercedes-Benz 190E 2.5-16 Evolution 2, Ford Escort Mk1 RS1600, and Alfa Romeo Giulia Sprint GTA. Note that all these cars share the same design—bonnet at the front, and boot at the back. By that, I mean they are all rear wheel drive, lightweight saloons, powered by a sprightly, four-cylinder inline engine at the front. And I strongly recommend that you try out the Caterham Superlight R500, which is a modernised version of the fabulous old girl, Lotus Seven.

car set-up — upgrades

A common misconception among car enthusiasts is that the only cars worth racing are those exotics with enormous engines and exorbitant prices. In truth, any well set up, rear wheel drive car with harmoniously chosen power, weight, and traction design parameters has a potential to be fast on the track. Moreover, driving a well-balanced car at racing speed is loads of fun. Why did I single out rear wheel drive cars? The answer, as I explain later in this chapter, is the combined effect of load transfer and tyre traction capacity.

In contrast, installing a monstrous engine that overpowers the suspension's design limits and the tyres' traction capacity will make the car uncontrollable in corners. Conversely, slapping on a set of modern, super-adhesive boots on a classic race car originally shod with less efficient tyres from a bygone era will likely make the car so docile as to sap the fun out of driving. Slapping on the best of everything is not always the best for every situation. When upgrading a race car, strive for balance.

I am assuming that you are starting with a fresh installation of S2U, hence you have no virtual money with which to purchase the upgrade parts. This is why I chose the E30 M3 for you. Even in its stock configuration, this car is really quite good. Nevertheless, I have a get-rich-quick plan for you; read on.

The designers of S2U intend for you to endure a series of mind-numbing races on dull, short tracks against a bevy of inept, computer-generated opponents, before you earn a sufficient amount of virtual money to buy a competitive car. This is not to be borne. We had already remedied part of this problem by purchasing the time-saving, add-on packs, with real money. However, even a good car like the M3 has room for improvement. The add-on packs do not come with free upgrade parts. So, you are still obliged to earn some virtual money, in order to procure the upgrade parts.

I have a radical solution for your indigence. Forget those dumbed-down races. Just focus on learning the Nordschleife, sector by sector, in your stock M3 in one-man, rigged races in the **Quick** screen, which is reachable from the main screen. S2U provides three sectors of Nordschleife: Aremburg, Karussell, and Nürburg. Focus on one sector per day. Repeat the sector a few times in each session, so as to improve your visual and muscle memories. Since these quick races have no opponents, you will earn no money. But you will gain a handful of experience points (XPs), each time you complete the sector. Once you have amassed enough XPs, you will advance to the next level. At that point, you will be rewarded handsomely in virtual money. I believe this is a fast, fun, and fruitful way to earn virtual money. Once you have earned enough to upgrade your race car, the fun increases even more.

On the downside, your career progress will be nil. If you wish to earn career points, you must participate in the sanctioned races against the pillocks the simulator tosses onto the track to oppose you. These races may be found in the **Career** screen, from the main screen. On the upside, as your experience level rises, a slew of interesting career races open up, pitting you against better opponents in more capable cars. Collecting career points is not my cup of tea. And this book is not a strategy guide on how to rise up in S2U's career ladder. So, this is all I have to say about career points.

After you have amassed a small fortune in virtual cash, let us now spend some of it. First, select the M3 as your current car by entering the **My Cars** screen via the **Garage** menu in the main screen. Scroll down to the BMW logo, and choose the red BMW E30 M3 Sport Evolution. This is the road-going, stock M3 you acquired earlier form the car lot. To upgrade your stock M3, return to the main screen, and enter the **Upgrades** screen, via the **Garage** menu. The following are the upgrades I suggest you acquire. They are listed in the descending order of priority, in case your funds are somewhat limited.

weight

In general, your first upgrade expenditure should be on weight reduction. I shall explain this matter more fully, in the next chapter. To reduce your car's weight, select the **Body** upgrade category, switch to the **Weight Reduction** page, and purchase *Competition weight reduction*. This reduces your stock M3's weight by 10%, from 1200 kg down to 1080 kg. Smashing!

I subscribe to Colin Chapman's car design philosophy: attain speed through lightweight and handling, not by brute power. A heavy car with a big, powerful engine may well be peerless on a straight, but this beast will surely be stung at the entry of the first corner by a mosquito propelled by a smaller, lighter engine. Chapman was the brilliant race car designer and the founder of Lotus Cars. His beautiful cars were innovative and fast, but had a reputation for—how shall I put it delicately—being delicate. Fortunately on the simulator, we need not concern ourselves with the durability problems associated with lightweight components.

Ignore the aerodynamic body kit for now; you do not need it, yet. And the race level cockpit upgrade is but an eye candy, yielding no performance gains. It costs a great deal of money, and the roll cage tubes cut into your field of view. But it does enhance the realistic look of your simulated race car.

One glaring omission in S2U and other console-based simulators is the ability to set the fuel amount. As the lap count goes up and the fuel burns away, the car weight distribution changes. This can have a dramatic impact on the car behaviour. It does not appear that S2U simulates this effect.

suspension

Select the **Suspension** upgrade category, and purchase *Race coilover suspension*. This upgrade makes your M3's suspension fully adjustable, that is, to the full extent that S2U permits. Do not bother with the cheaper upgrades. Save your money, and spend it on the racing suspension. Adjustability is essential, if you want a car that behaves reasonably well through different types of corners on a variety of tracks.

brakes

Select the **Brakes** upgrade category, switch to the **Upgrades** page, and purchase *Competition brake set-up*. This upgrade equips your car with racing rotors and callipers.

And if you have the means, purchase *Dual master cylinder assembly* in the **Accessories** page. This option allows you to adjust the brake pressure sensitivity and the brake bias.

drivetrain

The drivetrain comprises the engine, the transmission, the drive shaft, the differential, and the drive wheels. Select the **Drivetrain** upgrade category, switch to the **Transmission** page, and purchase *Quick change gear stacks*. This upgrade allows gear ratios to be changed, thus allowing you to alter the individual gears to suit the track and your driving style. A shorter gear ratio yields better acceleration, but a longer ratio yields better top speed.

Next, switch to the **Clutch** page, and purchase *Feramic puck disc assembly*. This upgrade quickens gear changes, and prevents clutch slippage. The slipping clutch plates burn off the initial surge of rotational energy produced by the engine, instead of transmitting it down the drivetrain. This momentarily robs acceleration, especially when you need it the most, such as when launching off the starting line.

If you still have some loose change jangling in your knickerbockers, purchase *Race differential standard – 2 way adjustable* in the **Differential** page. This upgrade lets you alter the manner in which the differential divvies up the engine power to the drivewheels during acceleration and deceleration, thereby allowing you to refine the cornering behaviour (the oversteer-understeer balance while cornering).

tyres

There are three tyre grades in S2U: high performance street tyres, track tyres, and semi-slick tyres. You can drive in a spirited manner on the high performance street tyres, which are the next grade up from the standard street tyres that come with your stock M3. For casual races in a lower power car, choose the track tyres. When driving an upgraded race car, choose the semi-slicks.

A modern racing tyre generates much greater traction than a street tyre. Racing tyres have wider tread, which gives wider contact patch. They are constructed from stickier, softer rubber compound. The softer racing tyre reaches its optimum operating temperature more quickly than the harder street tyre. But even with the semi-slicks, the car will feel a bit slippery for the first couple of minutes after the start, because the tyres are still cold. And the softer racing tyres wear out more quickly than the harder street tyres. So, drive fast, but be smooth. Aggressively manhandling the car will scrub off the tyre treads.

As your car's engine becomes more powerful and drivetrain becomes more efficient through upgrades, you will need to upgrade to softer tyres to gain the extra grip. But if you spent all your money on the engine upgrades and are unable to purchase better tyres, you will have in your hands a car with anger management issues. So, upgrade your tyres first, then the engine. Fortunately for us, the standard street tyres on your M3 are well suited to it stock engine.

I must say though that even after having driven at race pace for five laps, non-stop, round The Ring, which is about twice the distance of a modern F1 tyre's lifespan, this set of semi-slicks felt as though they were still in their prime. I am not asserting that S2U's fictitious semi-slicks should have an identical lifespan as F1's Pirelli super softs. But a set of soft semi-slicks exhibiting no perceptible indicia of degradation after 100 km at speed is hard to countenance. S2U's FAQ site claims that the model of tyre wear is "pretty realistic." I respectfully disagree.

engine

Frankly, the stock M3 is underpowered for a challenging track like the Nordschleife. To upgrade the engine, select the **Engine** upgrade category. If you have the funds, purchase all the racing engine upgrades, but forego the $10,000 **Engine Swap** option. This replacement engine—the 487 HP, V10 monstrosity—is the lump that fell out of a modern M6. This unseemly modification will overpower your petite M3. Similarly, do not be hoodwinked into buying the pricy turbo and the noxious nitrous kit. Our goal is not bonkers straight-line speed, but balanced improvements in both performance and handling. And remember, it is not the absolute engine power that matters, but the power-to-weight ratio that does.

If you are light on funds, make incremental purchases, starting with *Higher compression forged pistons* from the **Block/Lower End** page. The Ring is a twisty, undulating track that requires loads of braking and acceleration. So, prioritise your engine upgrades based on acceleration. Buy the one that yields the shortest 0-100 kph acceleration time, then the next one down, and so on, until you are destitute. This theoretical acceleration time is shown in the upgrade screen. If an upgrade part offers no discernable improvement, skip it.

aerodynamics

After you have made your engine more powerful, consider installing aerodynamic aids. Select the **Body** upgrade category, switch to the **Bodykits** page, and purchase *Bodykit 3*, which appears to be the only kit available to install. This upgrade gives you the ability to adjust the downforce, both at the front and the rear of the car. These aero appendages may well make the air flow smoothly over the body, but they do disrupt the sleek lines of the car. I suppose it is better for a race car to be fast than be fetching.

My preference, however, is to replicate the performance, handling, and visual characteristics of the renowned Deutsche Tourenwagen Masters (DTM) factory race car of the late 1980s, as shown below. To replicate the DTM look, I installed the roll cage and the gold rims. I also chose to retain the factory rear spoiler, because this was how the DTM M3 was outfitted. Installing the highest upgrades for the engine, drivetrain, chassis, and tyres—except the neurotic M6 replacement engine—gave me the performance characteristics similar to the DTM race car, with the PI of B 1105.

Here is a top tip before we move on to tuning: keep multiple performance group versions of the same car, funds permitting of course. This way, you can participate in various on-line races requiring different performance groups. For instance, the stock E30 M3 has a PI of 400, so it is in Group D. Acquire another E30 M3 from the **Car Lot**, and upgrade it so that the PI gets as close to the Group D maximum of 499. Get another E30 M3, and install all the sensible upgrades—weight reduction, race suspension, semi-slick tyres, etc. If you install all of these upgrades, your M3 will get up to the low end of Group B, like my DTM race car lookalike shown above. But for on-line racing, it is better to be at the top of Group C than at the bottom of Group B. So, uninstall a few upgrades, until the PI is at or near the Group C maximum of 999. In general, avoid the *Works Conversion* upgrade, when tuning classic race cars. This upgrade is better suited for the modern exotics. Finally, use different paint colours to distinguish the upgraded cars.

car set-up — tuning

Notwithstanding the upgraded components, to extract the best out of your car, you must adapt the car's behaviour to the track characteristics, environmental conditions, and your driving style. That is, we must tune the operating parameters of the installed components.

In real life, tuning a car is a laborious process that includes the following tasks: identify the ills the car is suffering on track; vary a parameter of a component by a small increment; re-evaluate the handling and performance characteristics of the car on track; and repeat the process until the lap times improve, the track closes at sunset, or the money runs dry. The resulting car configuration is called a set-up. Car set-up is a vast topic that has been studied thoroughly for several decades, and blokes far cleverer than I have written tomes on the subject. I recommend Carroll Smith's book *Tune to Win*, as a starting point.

Because there are a great many theoretical and practical books on race car tuning, I will focus on those aspects of tuning as they pertain to S2U, here. Tuning can be exasperating in real life. A set-up that worked well in the morning test session may not work at all in the afternoon, due to different weather conditions, track surface changes, or something that the driver ate for lunch. Comparatively, setting up a simulated car is far easier, but it does have its unique challenges. One does not get the seat-of-the-pants feel when driving a simulated race car, so it can be difficult to discern the subtle ways in which the car responds to small changes in set-up. So, as with a real race car, setting up a simulated race car demands a modicum of assiduity.

adjustable components

The dual goals of tuning—improved handling and increased performance—may be achieved in S2U by adjusting the stance (ride height), suspension (bump stops, anti-sway bars, springs, dampers), steering (lock, castor), wheels (toes, cambers, tyre pressures, tyre compounds), brakes (pressure, bias), and drivetrain (gear ratios, differential lock, final drive). To my knowledge, no consumer-grade racing simulator permits the user to alter the dimensions and the geometries of the upper and the lower wishbones.

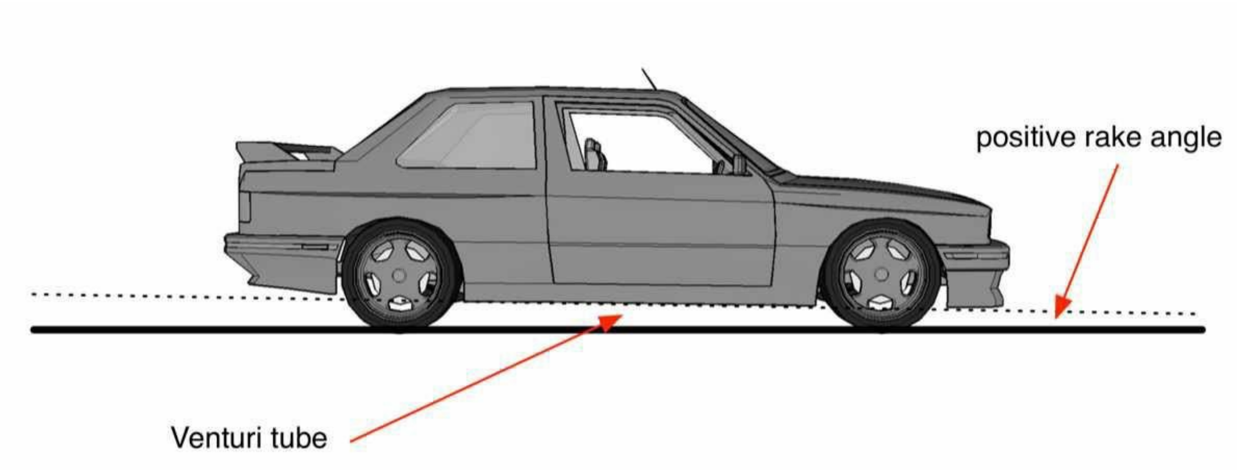
When tuning a race car, you aim to keep its tyres in contact with the track surface at all times, under all circumstances, all over the track. Additionally, you want to deliver all the available engine power to the drivewheels. Simple, yeah? No, not quite. You will never achieve these twin ideals, in practice. Setting up a car, like any engineering endeavour, is an exercise in compromise. Even finding the right compromise is difficult, because there are loads of adjustable components, each with a range of possible settings. To make matters worse, an adjustment made to a component can express its effects in multiple ways, some anticipated, some not. And an adjustment made to one component may affect the behaviour of other components.

Now, I shall explain car set-up from two perspectives: a car-centric view, and a driver-centric view. First, I will present the race car components and their functions. Then, I will explain which components to adjust and how to adjust them, in order to make the car behave the way the driver wants.

ride height

Ride height determines how far off the ground the bottom of the chassis is, when the car is sitting on level ground. If the ride height is too high, the car will wallow like a bendy bus. Lowering the ride height lowers the car's centre of mass, thereby resulting in less body movement while manoeuvring. This improves handling. But lowering the ride height in excess will cause the chassis to scrape the ground. This is called *chassis bottoming*, and is as enjoyable as hydroplaning.

The stance of the car is the angle at which the car sits on level ground—that is, the difference in height between the front and the rear of the chassis. A positive rake with a slightly lower front produces an extra bit of aerodynamic downforce, in addition to the downforces generated by the front air dam and the rear wing. This additional downforce is due to the Venturi effect generated by the air that flows through the wedge-shaped tunnel under the car. This tunnel is formed by the chassis tray and the track surface, as shown in the figure[1] below.



The rear of the race car chassis is either higher than the front or is at the same ride height, but never lower. Usually, the front and the rear ride heights are set so as to obtain a positive rake angle of about two or three degrees. Too great a difference in ride heights makes the rear of the car vague and unstable.

bump stops

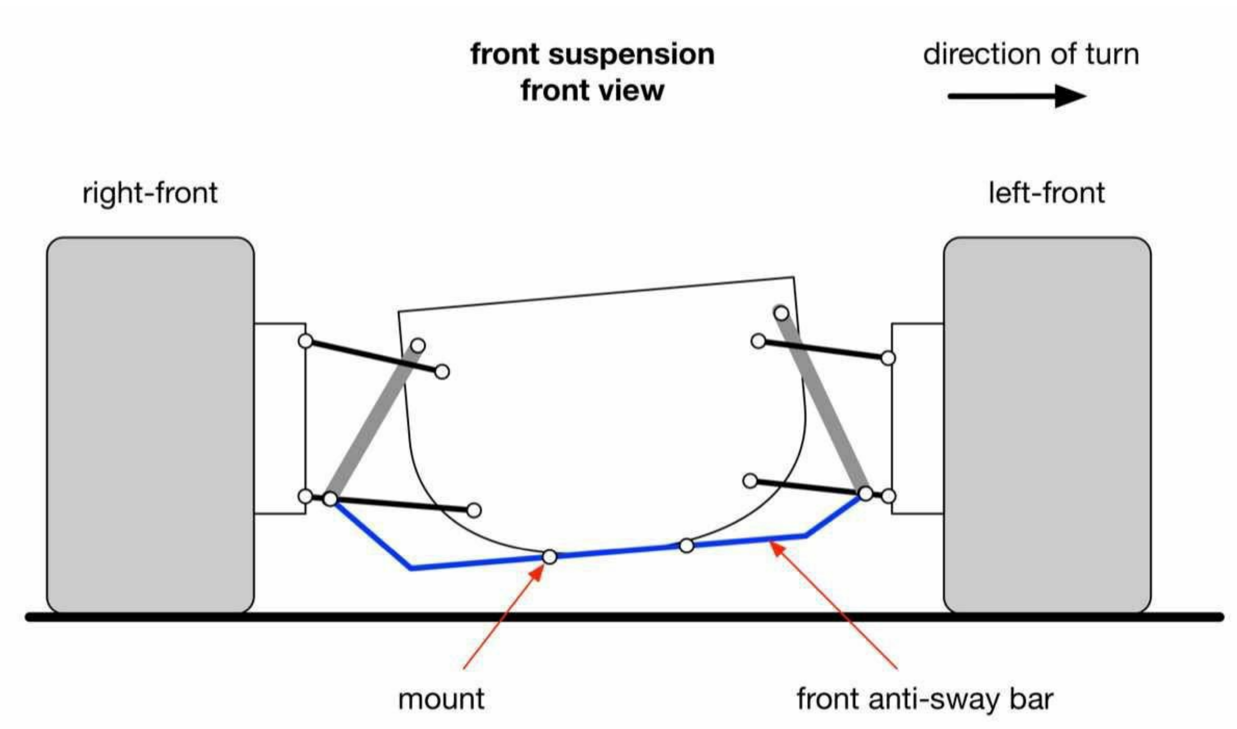
Bump stops are small rubber cones that prevent the tops of the suspension components from gnashing into the underside of the chassis, during a hard jounce. This metal-on-metal contact is called *suspension bottoming*. It is a bad thing, because when it occurs, the suspension at that corner of the car loses all its compliance, leading to a loss of control. The rubber bump stops prevent this catastrophic outcome.

The suspension is more likely to bottom, when the track bumpy, the springs are soft, the ride height is low, and the car is equipped with high-downforce wings. In that case, the suspension will certainly bottom, when the car is barrelling down the straight. So, you will need a dab of bump stops all round. These rubber cones are designed to become progressively stiffer as they are compressed, similar to the way the suspension springs behave. But being much stiffer than the springs, these rubbers do not provide much compliance. Riding on the bump stops should be the last resort. So, do not lower the ride height too much, in reliance of the bump stops.

anti-sway bars

A typical modern race car has a *fully independent suspension*, which allows the four wheels to act independently of one another. Hence, the ill effects in one corner of the car do not propagate to the other three corners. For instance, when the right-front wheel hits the apex kerb, the other three wheels remain relatively steady. This independence improves the overall grip. But sometimes, we must sacrifice some independence in exchange for a better control of body roll.

At mid corner, the car's body rolls onto the outside suspension, due to lateral load transfer. If the body roll is excessive, it not only compresses the outside suspension beyond the design limits, it also extends the inside suspension beyond the design limits, wreaking havoc with tyre traction, all around. A simple method of mitigating excessive body roll is to tie the inside and the outside suspensions with a U-shaped rod called the anti-sway bar, commonly referred to as anti-roll bar. The stems (the vertical bits) of the U are relatively short, compared to the bar (the horizontal bit) of the U. The bar of the U is attached to the car's chassis using two mounts that allow the bar to twist in place. One stem of the U connects to the left side suspension, and the other connects to the right side. And there is one anti-sway bar at the front, and another at the rear of the car. Varying the stiffness of the bars alters the oversteer-understeer balance of the car. The blue bar in the diagram below is a simplified representation of the front anti-sway bar.



When the car makes a hard left turn, as shown in the diagram above, the body rolls down onto the outside (right) suspension, thus compressing that suspension. At the same time, the other side of the body rolls up away from the inside (left) suspension, thereby extending that suspension. But because the anti-sway bar cross connects the two suspensions, each suspension acts as a restraint on the movement of the other. That is, the downward movement of the outside suspension restricts the upward movement of the inside suspension, and the upward movement of the inside suspension restricts the downward movement of the outside suspension. But the body is attached to the suspensions. So, restricting the relative movements of the left and the right suspensions restricts body roll. The stiffer the anti-sway bar, the more restricted the body roll.

A more massive body rolls more, so a stiffer anti-sway bar is needed to keep body roll under control. But if the bar is too stiff, it binds the left and the right side suspensions, thereby negating the benefits of an independent suspension system. And if the springs and dampers of the two suspensions are very stiff as well, body roll can lift the inside wheel clear off the track, resulting in momentary traction loss. When such a car turns hard into a corner, the inside-rear wheel may lift. When it accelerates hard out of a corner, the inside-front wheel may lift.

springs

Springs spare the car body, and the driver ensconced within, from the agony that the wheels suffer at the pleasure of a rough track. Springs that are too soft make the car behave like a drunken sailor. Too stiff though, and the car turns into an irascible peg leg pirate. Installing different rate springs at the front end and the rear end affects the car’s balance. Although it is possible to use different rate springs at each corner of the car, reason demands installing the same rate springs at each end. Indeed, S2U does not permit using different rates between the left and the right sides.

Note that changing springs usually requires changing dampers, because a stiffer spring stores more energy and thus requires a stiffer damper to dissipate that stored energy.

And stiffer springs and dampers can resist body roll better, so they need not rely on the anti-sway bars too much. Indeed, some cars allow the bars to be disconnected altogether. But a stiff suspension is less compliant, and it wreaks havoc with tyre temperatures. On the other hand, chasing compliance by excessively softening the springs and dampers, then over stiffening the bars to compensate does not pay, because stiff bars couple the left and the right suspensions. The increased compliance cannot make up for the loss of independence. What you should do is to aim for the springs and dampers settings that are just stiff enough to keep the tyre temperatures within optimum range, then control the body roll and cure the vague handling by stiffening the anti-sway bars, incrementally.

dampers

A car with only springs and without dampers will bound down the track like a well-hit golf ball. When a wheel encounters a bump, the spring absorbs the shock by compressing itself. A spring stores a large amount of energy when compressed, and releases this stored energy when it returns to its installed length. Unless this released energy is dissipated with a damper, the spring, and the attachments thereto, will continue to bounce like a golf ball on concrete. Stiffer spring stores more energy, so it requires a stiffer damper. Race car springs, in general, are slightly under damped. Indeed, a damper works both during jounce and droop (bump and rebound in S2U parlance). Because the term “bump” could also mean a track surface irregularity or a minor collision between two cars, I use “jounce” and “droop” in this book, instead of the more common terms “bump” and “rebound.”

A typical race-grade damper has four adjustments: fast jounce, fast droop, slow jounce, and slow droop. I describe what jounce and droop are, first. Then, I explain the differences between the fast damper settings and the slow damper settings. Finally, I combine jounce, droop, fast, and slow, and provide a detailed explanation of these four adjustments.

First, we shall talk examine the terms jounce and droop. A jounce stroke is when the spring compresses as the wheel moves toward the body. A jounce stroke occurs, when the wheel it climbs up a bump or hits a high kerb. A droop stroke is either when the spring returns to its installed length from a compressed state, or when the spring extends beyond its installed length. A droop stroke occurs, when the wheel drops away from the body, such as when it goes over the crest of a bump and drops down the other side, or when it dips into a large pothole.

During a jounce stroke, the spring is assisting the damper to control the wheel’s upward movement. During a droop stroke, however, the damper must resist not only the wheel’s weight but also the spring’s tendency to return to its natural state. Hence, it is reasonable to set the jounce damper settings a bit softer than the droop damper settings.

Now, let us tackle the fast and slow damper settings. The fast damper setting determines how stiffly the damper resists the movement of the wheel during a sudden transition, such as when the wheel hits a bump or a pothole. The slow damper setting is at work, when the car goes through a gradual transition, such as when the body dives and rolls as the car slows down and turns into a corner.

In simple terms, the fast damper setting controls the movement of the wheel, whereas the slow damper setting controls the movement of the car body, which is considerably more massive than a wheel. Hence, it is appropriate to set the slow damper settings a lot stiffer than the fast damper settings.

I find these four damper settings comprehensible individually, but confusing when combined. So, I shall summarise them below for added clarity:

Fast Dampers:

- Fast jounce:
  - controls wheel movement, so set a lot softer than slow dampers
  - is assisted by spring, so set a bit softer than fast droop
- Fast droop:
  - controls wheel movement, so set a lot softer than slow dampers
  - is opposed by spring, so set a bit stiffer than fast jounce

Slow Dampers:

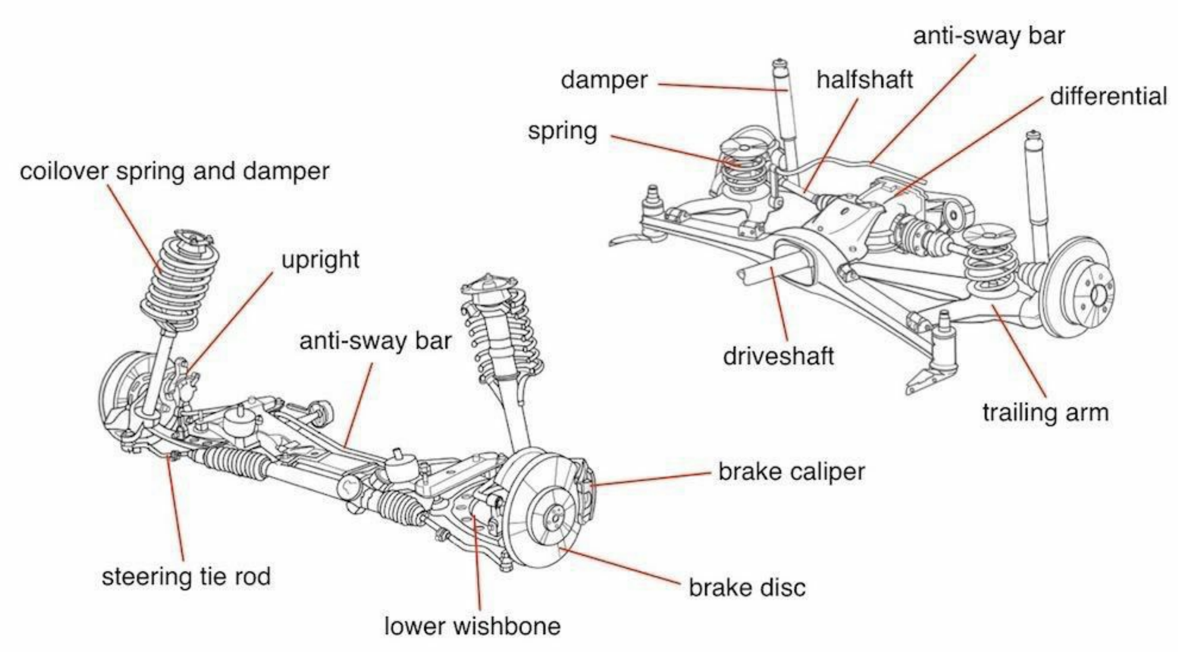
- Slow jounce:
  - controls body movement, so set a lot stiffer than fast dampers
  - is assisted by spring, so set a bit softer slow droop
- Slow droop:
  - controls body movement, so set a lot stiffer than fast dampers
  - is opposed by spring, so set a bit stiffer than slow jounce

Hence, we may reason that the four damper settings may be enumerated in the ascending order of relative stiffness:

- Fast jounce: a lot softer + a bit softer = softer
- Fast droop: a lot softer − a bit stiffer = soft
- Slow jounce: a lot stiffer − a bit softer = stiff
- Slow droop: a lot stiffer + a bit stiffer = stiffer

Do not interpret the adjectives “a bit” and “a lot” literally. I use these modifiers as a convenient means to highlight the relative differences in stiffness among the four settings. So, by “a lot stiffer,” I do not mean for you to crank up the damper stiffness to excess. And remember, stiffer spring requires a stiffer damper, and vice versa.

The race coilover suspension upgrade component mentioned in the previous subsection is a spring-damper installation in which the spring wraps round the damper. This configuration is preferred in racing, because in such an installation, both the spring and the damper have the same amount of leverage, and they move in unison to the same extent. This makes it more convenient for the race engineer to calculate the suspension set-up parameters. The stock E30 M3’s front suspension is of a coilover design called MacPherson strut, as shown below, but the rear is a non-coilover design called trailing arm. Note that the figure[2] below does not show the upper wishbone of the front suspension.



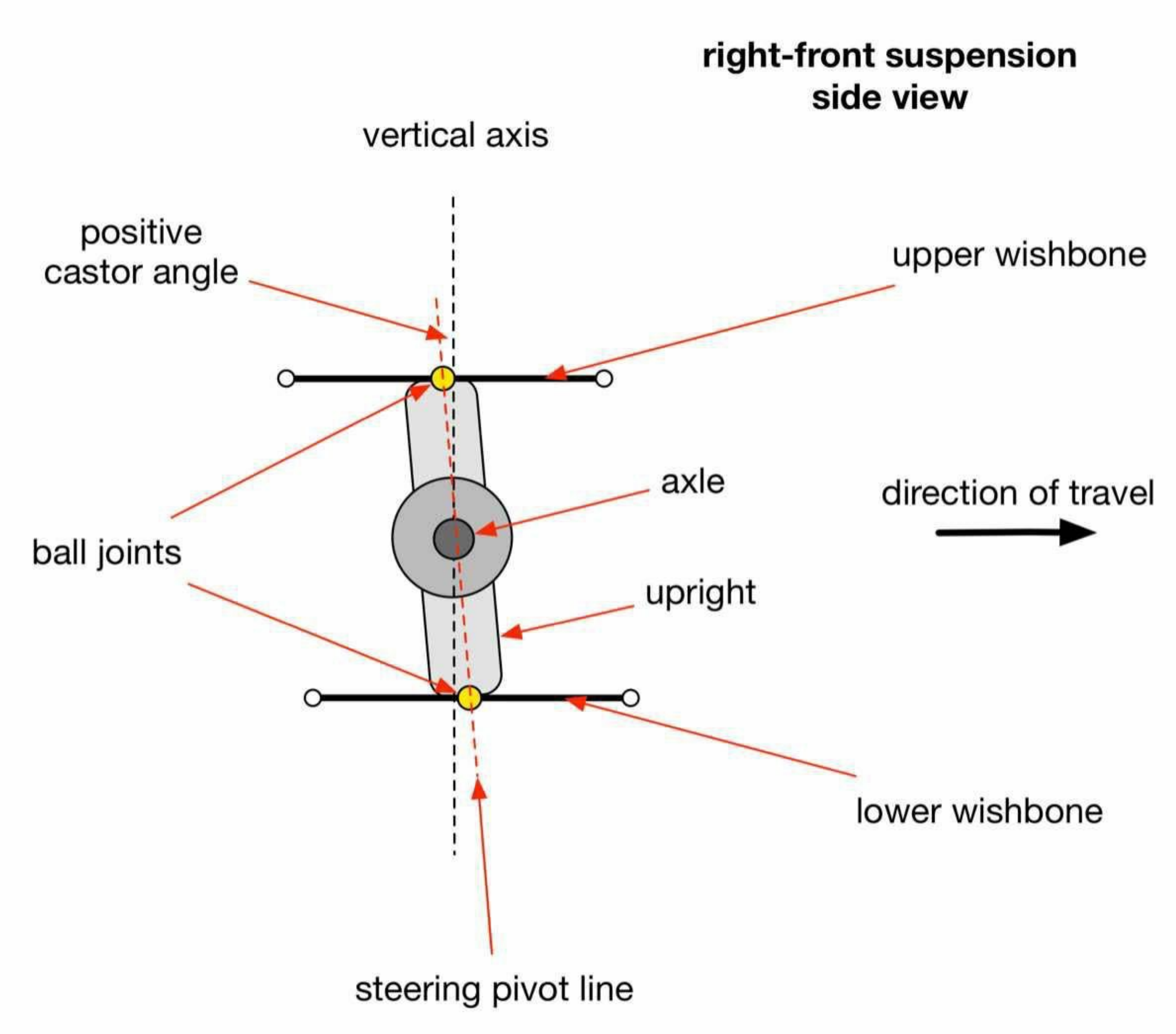
In race engineering, the car body is called sprung mass, because its weight is supported by the suspension springs. The wheel is called unsprung mass, because although it is attached to the suspension, its weight is not supported by the suspension spring. It helps to know these engineering terms, because you will encounter them in academic writings such as peer-reviewed papers and mechanical engineering textbooks.

steering lock

Steering lock is the extent to which the front wheels turn, as the steering wheel is rotated, lock-to-lock. Tracks with sharp hairpins require more lock. Greater degree of steering lock allows the front wheels to turn more for the same amount of steering wheel rotation. This makes the steering feel more sensitive.

castor angle

Castor angle is the angle between the steering pivot line and the vertical axis, when viewed from the side. In the diagram below, the pivot line is the red dotted line that goes through the top and the bottom ball joints of the front wheel uprights. A positive castor created by a backward leaning pivot line, as shown in the diagram, provides better straight-line stability, because it increases the self-centring tendency of the steering mechanism. But too large a castor angle can make the steering lethargic, or worse—apathetic to the driver’s plight.



Now, let us examine how the castor angle affects the self-centring tendency of the steering wheel, hence the car's stability, indirectly.

The forward thrust generated by the rear drivewheels is transmitted to the front wheels through the car body. A front wheel is attached to the front upright, so the front upright is the component that delivers the forward thrust to the front wheel, via the front axle. To analyse the geometric relationship between the thrust force and a front tyre contact patch, we project the thrust force along the pivot line (the upright's rotational axis) onto the track surface.

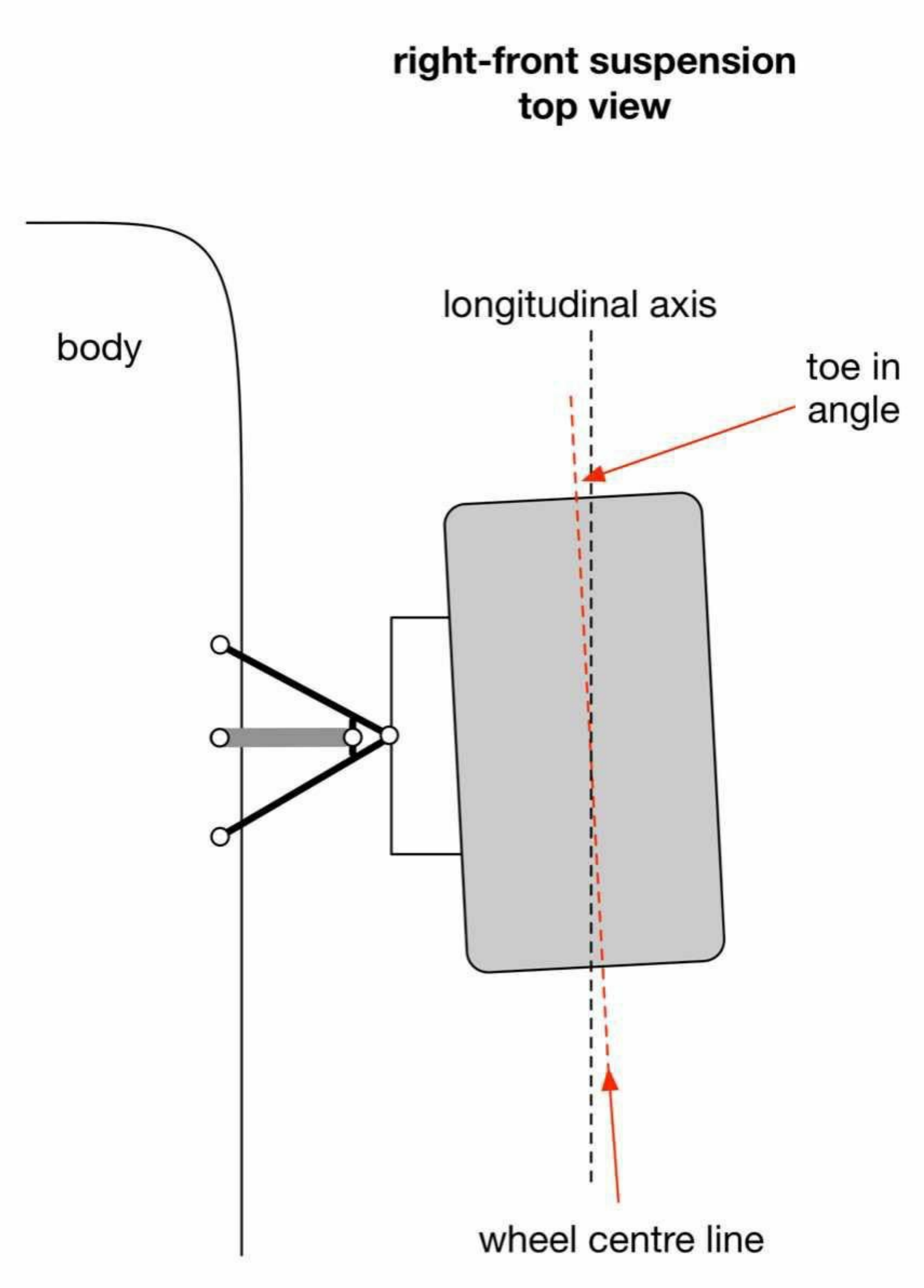
The tyre contact patch is centred at a point where the wheel vertical axis intersects the track surface. The inclination of the pivot line is such that if the axis is extended downward, it intersects the track surface at a point ahead of the tyre contact patch centre. So, the thrust force application site is in front of the tyre contact patch. In effect, the thrust force is pulling the tyre contact patch from the front. When the front wheel points slightly off centre, the front tyre's contact patch begins to stray off the longitudinal axis along which the thrust force acts. Then, the trust force pulls the contact patch back in line, thus giving rise to the self-centring steering effect. This is a stable configuration. This is why a tractor pulls its trailer.

If the castor angle is made negative, that is the pivot line leans forward, then the thrust force would be pushing the tyre contact patch from the rear. This configuration is unstable. It is as barmy as a tractor attempting to push its trailer. But for a heavy car that is reluctant to turn, a bit of negative castor angle maybe just the right cure. Personally, I have never seen a track-racing car that employs a negative castor angle.

With most cars in S2U, the default steering geometry settings—castor angle, toe angle, and camber angle—work reasonably well. Play with these settings, only if the steering is still vague, after having exhausted all the suspension adjustment options.

toe angle

Toe angle is the angle between the longitudinal axis of the car and the wheel centre line, viewing from above. Toe in, where the front parts of the wheels point toward each other when viewed from above, as shown in the diagram below, yields greater straight-line stability at the cost of manoeuvrability.



Toeing in the front wheels improves straight-line stability, because when traveling along a straight, both wheels seek the centre. This is like two drunks waddling along a pavement by leaning on each other's shoulder. But there is an attendant decrease in cornering ability, because when the car rolls into the corner, the toed-in inside front wheel points a bit outward compared to the outside front wheel, which is doing most of the work of steering the car along the curved path. So, the inside front wheel resists the outside front wheel in a corner.

Conversely, toe out improves cornering, because the toed-out inside front wheel points further inward than the outside front wheel, and the two front wheels work together to complete the turn. The cost of toe out is the reduced straight-line stability, caused by the two wheels attempting to dissolve their blissful union by running in opposite directions away from the centre.

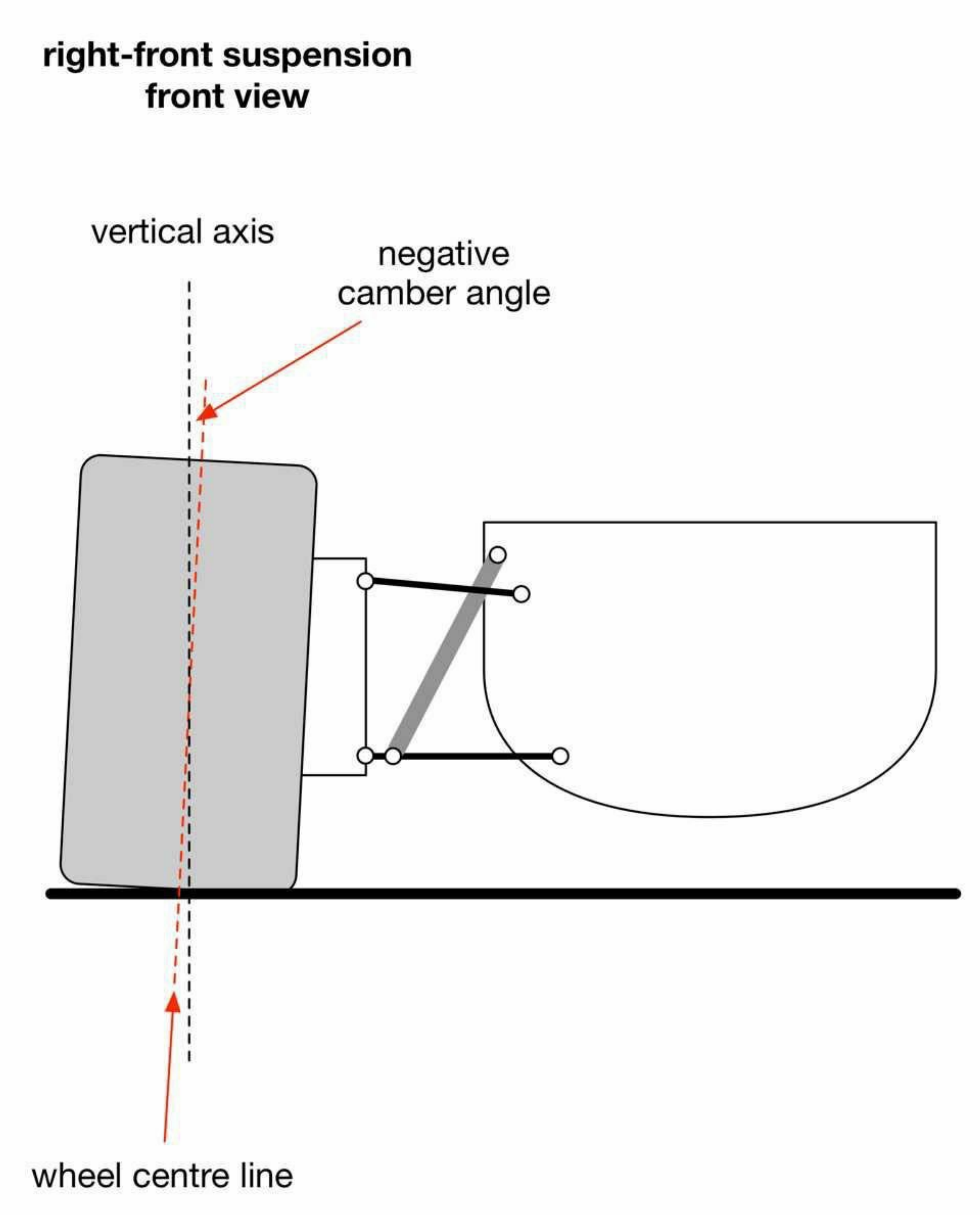
The rear wheels are typically set with a small toe-in angle, if at all, since toeing the rear wheels reduce their traction during acceleration. I suggest you stay away from toeing out the rear, unless you enjoy riding a car with a rear end that flicks like the tail of a great white shark.

There is a condition called bump steer, which describes the front suspension's tendency to alter the toe angle of the front wheels, when both wheels encounter a jounce, such as when going over a bump or when braking hard. A related condition is called roll steer. It affects the front wheels' toe angle, when one wheel is in jounce and the other is in droop, such as when the car rolls into a corner or when the inside front wheel hits the apex kerb. Both conditions are undesirable, since they tend to pitch the car unpredictably to the left or to the right.

Adjusting the suspension geometry and steering geometry, such as the lengths of the wishbone arms and the tie rod, may alleviate the symptom. But no consumer-grade simulator I have driven permits the user to adjust the suspension geometry and steering geometry to this level of detail. So, I will not go into more details on the matter. Just remember that if your car is swerving over uneven surface, it may be suffering from these conditions. In that case, your only recourse is to tweak the toe angles, which may or may not solve your problem. But at least you now know the symptom and its causes.

camber angle

Camber angle is the angle between the vertical axis and the wheel centre line, when viewed from the front as shown in the diagram below. When the race car turns into a corner, the body rolls and leans onto the outside wheels, squishing the outside suspension and causing the laden wheel to lean outward at the top. When a wheel leans, its contact patch area decreases, and concomitantly its traction capacity. But by tilting the wheels in negative camber by tipping their top parts inward, the outside wheels become upright when the body leans hard on them during cornering, thus improving traction when it is needed. The down side is that camber decreases straight-line acceleration and braking performance.



The outside front wheel is the one that bears most of the burden when entering a corner. During corner entry the car is decelerating and cornering simultaneously, thus the body is leaning forward and outward onto the outside front wheel. An appreciable amount of negative camber is needed at the front wheels for this reason. Too much negative camber at the rear reduces traction at the drivewheels during acceleration. Hence in general, the front wheels have greater negative camber than the rear wheels.

tyre pressure

Tyre pressures affect the balance of the car, noticeably. It is understandable, since even the most advanced modern cars are at the mercy of four little contact patches, each no bigger than a shoe print. Lower pressure improves tyre compliance and traction, but the resultant higher friction robs speed. Higher pressure has the reverse effect. Too low or too high a pressure not only produces ill handling, but also shortens tyre life.

Tyre pressure also contributes to the suspension stiffness calculations. Lower pressure makes the tyre more compliant, and higher pressure makes it stiffer. Hence, the overall stiffness of the suspension is a function of the following: anti-sway bar stiffness, spring stiffness, damper stiffness, and tyre pressure. It is therefore possible to fine-tune car handling using dissimilar front and rear tyre pressures. In real life, this is a significant advantage, because it takes but a few seconds to adjust tyre pressure, where as changing anti-sway bars, springs, and dampers are tasks that require several mechanics and many cups of tea. Although it takes the same amount of effort on the simulator to change the tyre pressure as it is to change the spring rate, you should still develop the good habit of tweaking the tyre pressures before meddling with the complicated suspension adjustments.

brake pressure

This setting affects the amount of brake pedal pressure required to stop the car. The brake pressure should be set so that the pedal's effective range is as wide as possible, thus giving the driver broader latitude in modulating his foot pressure.

While this is an important adjustment to improve the feel of a real race car, it is redundant on a simulator, since we can achieve the desired effect by tweaking the pedal sensitivity in the simulator software set-up screen. Nonetheless, the ability to adjust the brake pressure is a nice touch that shows attention to detail on the part of the simulator developer. And it allows us to tune the brake pressure for each car, individually. Marks for S2U, there.

brake bias

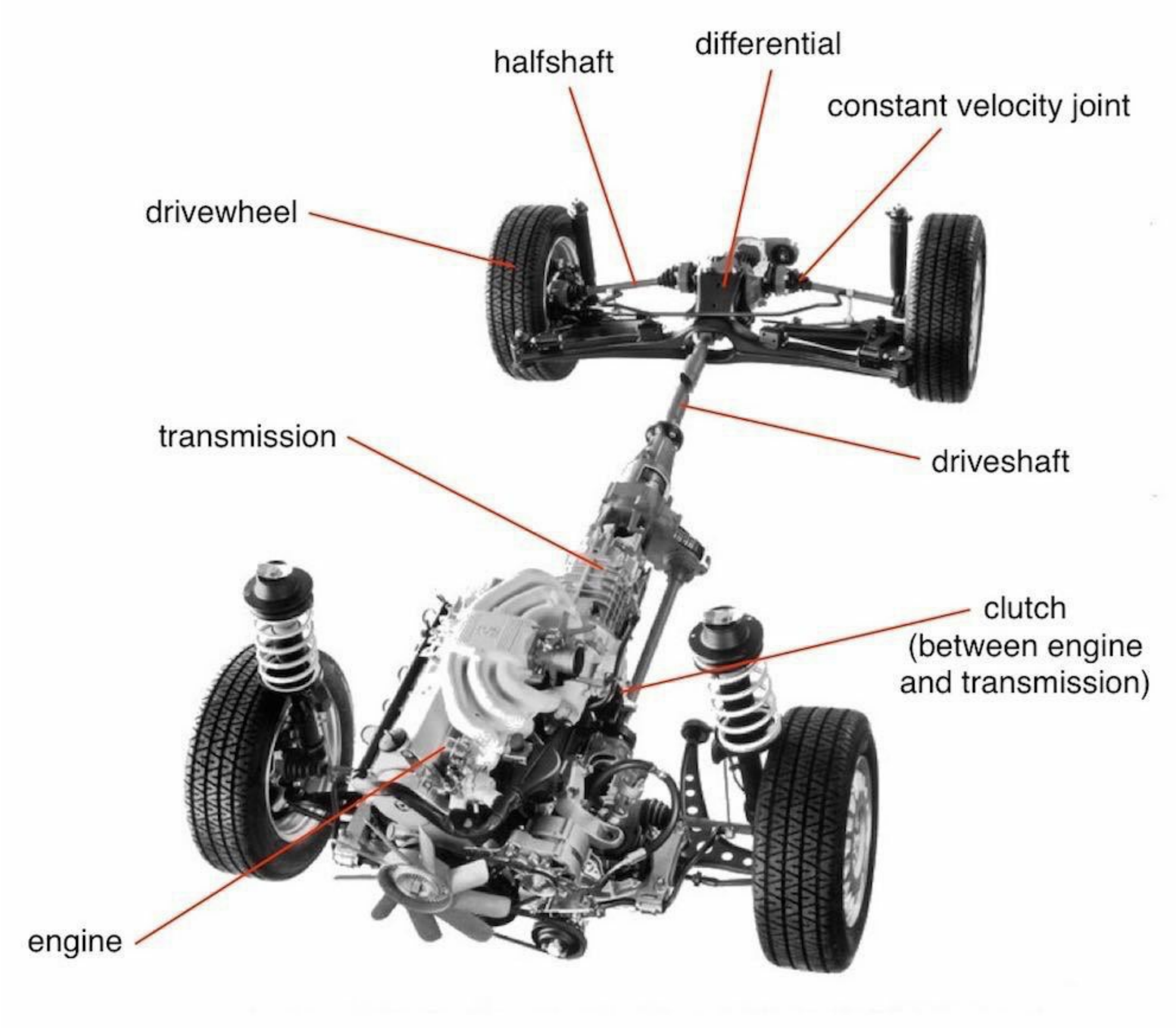
Brake bias allows the front and the rear brake pressures to be set inversely. Sliding the bias toward the front increases the front brake pressure and decreases the rear brake pressure, and vice versa. Ideally, you want the front wheels and the rear wheels to lock up at the same time in all corners of the track. Alas, that ideal is impossible to attain. So, your task as the driver is to find the compromise that offers the best braking performance in most corners. The appropriate bias setting depends on many factors—tyre compound, vehicle dry weight, fuel load, weather, driving style, slope of the track at corner entry, etc. In general, brake bias should be skewed slightly toward the front wheels, since they do most of the work when deceleration.

Proper race cars have an in-cockpit brake bias adjuster. It is used to alter the balance of the car, which inevitably changes during a long race, because the tyres wear out, the fuel burns off, and the weather changes. Indeed, it is now common for the F1 drivers to fiddle with the brake bias lever between corners, in order to extract the most out of the car at every corner.

But I suggest that you avoid getting into the habit of balancing the car with the brake bias, while experimenting with the set-up. Instead, balance the car mechanically and aerodynamically first, and use the brake bias only to maximise corner entry braking efficiency. This way, you will still have the in-cockpit brake bias adjustment as your last resort to restore balance during a long race.

gear ratios

To move the car, the engine's rotational energy must reach the drivewheels through a set of rotating shafts. The entire power delivery chain —comprising the engine, clutch, transmission, driveshaft, differential, halfshafts, and drivewheels—is called the drivetrain. A complete powertrain is shown in the photograph[3] below.



The transmission, also called the gearbox, reduces the high rotational speed of the engine to a lower speed suitable to drive the rear wheels. Different gears in the transmission allows the driver to run the engine at a constant, optimum RPM, even as the RPM of the drivewheels vary according to vehicle speed.

In a race car, the ratio of each gear in the transmission is independently adjustable to suit the speeds of various corners on the track. Gear ratio is the speed reduction ratio of a gear. For instance, the second gear on the stock US model E30 M3 has a 2.2:1 ratio. This gear rotates the driveshaft (output from the transmission) 1 turn for every 2.2 turns of the engine crankshaft (input to the transmission). Commonly, the fourth gear has 1:1 ratio. That is, the drivewheels turn once for every turn of the engine crankshaft. Lower gears—first, second, and third—are reduction gears.

They lean more toward torque than horsepower. So, they are used to accelerate out of corners. In contrast, higher gears—fifth, sixth, and seventh—are overdrives. That is, the drivewheels turn more than once for every turn of the engine crankshaft. They lean more toward horsepower than torque. So, they are used to attain top speed along straights.

The clutch plate, a friction device, acts as the buffer between the engine and the transmission. When you fully depress the clutch pedal, the clutch mechanism decouples the transmission from the engine. You may now shift the transmission into gear. Once the transmission is in gear, gradually release the clutch pedal. This progressively engages the engine and the transmission, thereby spooling the transmission's input shaft up to the speed of the engine's crankshaft. Now, the transmission's output shaft spins at the speed determined by the gear ratio. The rest of the drivetrain spins at the same speed, too. It is vital that you release the clutch pedal smoothly, in order to avoid upsetting the drivewheels.

final drive ratio

The final drive ratio is not a parameter of the gearbox, but of the rear differential. It equally affects the ratios of all the gears in the gearbox, lengthening or shortening all the gears at once. Some car-track combinations may require adjusting both the individual gear ratios and the final drive ratio. Think of the final drive ratio as a coarse adjustment, and the individual gear ratios as fine adjustments.

limited-slip differential

During hard cornering, the inside wheels unload due to body roll caused by load transfer. The tyre of the inside drivewheel (right rear) begins to lose traction and starts spinning. In this situation, the conventional open differential, by the nature of its design, delivers all the engine power to the free spinning inside drivewheel. The unhappy outcome is that the inside drivewheel, which is no longer able to propel the car, saps all the engine power, and leaves none for the outside drivewheel, which is still able to do its job. The limited-slip differential (LSD) mitigates this problem by progressively locking together the two drivewheels, thereby preventing the unloaded inside drivewheel from spinning. Hence, both wheels continue to propel the car forward.

The LSD permits independent adjustment of the coast side (decelerating) and power side (accelerating) differential lock amounts, thus allowing the car to behave differently during corner entry deceleration and corner exit acceleration. Another setting, preload, determines the amount of lock applied when in neutral throttle (neither accelerating nor decelerating). These three settings cover all three states in which the LSD operates—deceleration, neutral, and acceleration. The higher these values, the tighter the lock between the two rear drivewheels.

A locked differential obviously improves traction, but it has a negative side effect of reducing the car's ability to turn. The reason is when the differential is locked, the inside drivewheel continues to push the car straight on in opposition to the outside drivewheel's effort to propel the car along the curved, cornering line. This causes the car to understeer.

feel of the car

That was the car-centric description of race car components. I shall now present the terms a driver uses to describe the way the car feels on track. We will use the following driver-centric terms, when we talk about car set-up, later.

responsiveness

I use the term responsiveness to refer to the alacrity with which the drivetrain responds to the driver's throttle input.

manoeuvrability

I use the term manoeuvrability to mean the sprightliness with which the car's suspension obeys the driver's wheel-and-pedals input commands. A stiffer suspension set-up allows the car to settle more quickly into a new attitude. The driver perceives this as a manoeuvrable car, because the car obeys his commands with little or no reluctance. A stiff set-up sacrifices driver comfort, and more importantly traction, in favour of manoeuvrability. But as with all things engineering, there is a limit to how stiff you can make the suspension. If the suspension is too stiff, the wheels tend to skip over the bumps on the track, so the car loses traction. You must find the softness-stiffness compromise that suits your driving style and your car. Some people use the terms "responsiveness" and "manoeuvrability" interchangeably, so be attentive to the context in which these terms appear.

balance

When the car is balanced, it neither understeers nor oversteers during cornering. Understeer is a condition in which the front tyres lose traction before the rear tyres during cornering, thus the car is no longer able to stay on the racing line through the corner and slides, head first, to the outside of the corner. Oversteer is the converse condition in which the rear tyres lose traction before the front tyres, so the car spins round to the outside of the corner. Both conditions have undesirable consequence of the car leaving the track in disgrace.

A car with a slight understeer is easier to control, but can be frustrating to drive. And it will be slow, because the driver will have to lift the throttle in order to coax the car through the corners. A car with a slight oversteer is sprightly, and is fun to toss about on track. But it, too, will be slow, because the driver will be obliged to lift the throttle in order to avoid spinning out at corners. A well-balanced car is both fast and fun.

Improper set-up will cause to car to behave ill. Sometimes, a car starts the race in good behaviour, but as the tyres and the fuel burn off, it enters the adolescent phase and begins to act out. There is yet another cause of car misbehaviour: driving style.

Let us start with the driver-induced oversteer. A lot of drivers believe aggression equals speed. One sees rather a lot of tail-out driving, these days. That style of driving is loads of fun to be sure, but it is not fast. An aggressive driver commits two errors that cause *driver-induced oversteer*: (1) he cranks the steering wheel too aggressively upon entering the corner, and (2) he mashes the throttle too quickly at corner exit.

In the first case, the driver initiates corner entry by cranking the steering wheel much too aggressively. If the front tyres have sufficient traction capacity to dig themselves in, the car ends up in a corner-entry, snap oversteer.

In the second case, the driver gets back on the throttle too hard, as he exits the corner. The surge of power breaks loose the rear tyres, and corner-exit, snap oversteer results.

Let us now turn our attention to driver-induced understeer. An inexperienced driver commits two errors that cause *driver-induced* *understeer*: (1) he enters the corner carrying too much speed, and (2) he tries to get back on the throttle too early in mid corner.

Let us examine the first cause of driver-induced understeer. If the corner entry speed is excessive, all of the front tyres' traction capacity must be used to generate the drag necessary to slow down for the corner. And upon reaching the turn-in point, the driver initiates the turn without reducing brake pressure, because the car is still too fast. Hence, the already overworked front tyres are called upon to generate the centripetal force needed to keep the car on the cornering line. There is now more demand on the front tyres than their combined traction capacity can deliver, so the front end of the car breaks loose, and corner entry understeer ensues. By the way, corner entry understeer is a favourite ailment drivers cite to excuse themselves of their lacklustre lap times.

Now, we shall discuss the second cause of driver-induced understeer. In the early phase of cornering when the front wheels are still turned toward the apex, most of their traction capacity is used to generate the centripetal force. If the driver gets back on the throttle with the front wheels askew, the increased forward thrust places additional demand on the already overworked front tyres, and mid corner understeer results. When the driver senses the steering goes light due to understeer, his inexperience prompts him to crank on more steering, which twists the front tyres beyond their slip angles. The front end breaks loose, and the car lunges headlong toward the outside barrier. In a panic, the driver lifts off the throttle more than is necessary, or worse, he slams on the brake and worsens the understeer. In the best of circumstances, this is a massive waste of time and tyre. Heed Sir Jackie Stewart's words of wisdom. When coming out of a corner, he said, "Never press the gas pedal, until you know you never have to take it off." This advice speaks of the judgement, commitment, and smoothness necessary to execute a turn, properly.

In real life, the cure for drive-induced oversteer and understeer is to replace the driver. But in our case, we must modify our behaviour. It may well be fun to throw the car about on track, but it wastes resources and produces slow lap times. So, be smooth.

compliance

Compliance is the ability of the suspension to keep the wheels in contact with the track surface and to shield the car and the driver from the punishing bumps and dips on the track surface. The suspension should be set up so that it is as stiff as possible, without losing too much compliance. An overly soft suspension will make the car float like a boat on choppy sea. At the very least, this will make for an exasperating drive.

stability

A stable car tracks a straight-line, without requiring the driver to do a lot of work. A car that is stable does not wander side to side, when accelerating and decelerating in a straight line. It also minimises tyre scrubbing, while travelling along the straight. In other words, stability affects the longevity, balance, and performance of the car. But if the car is overly stable, it can hinder manoeuvrability.

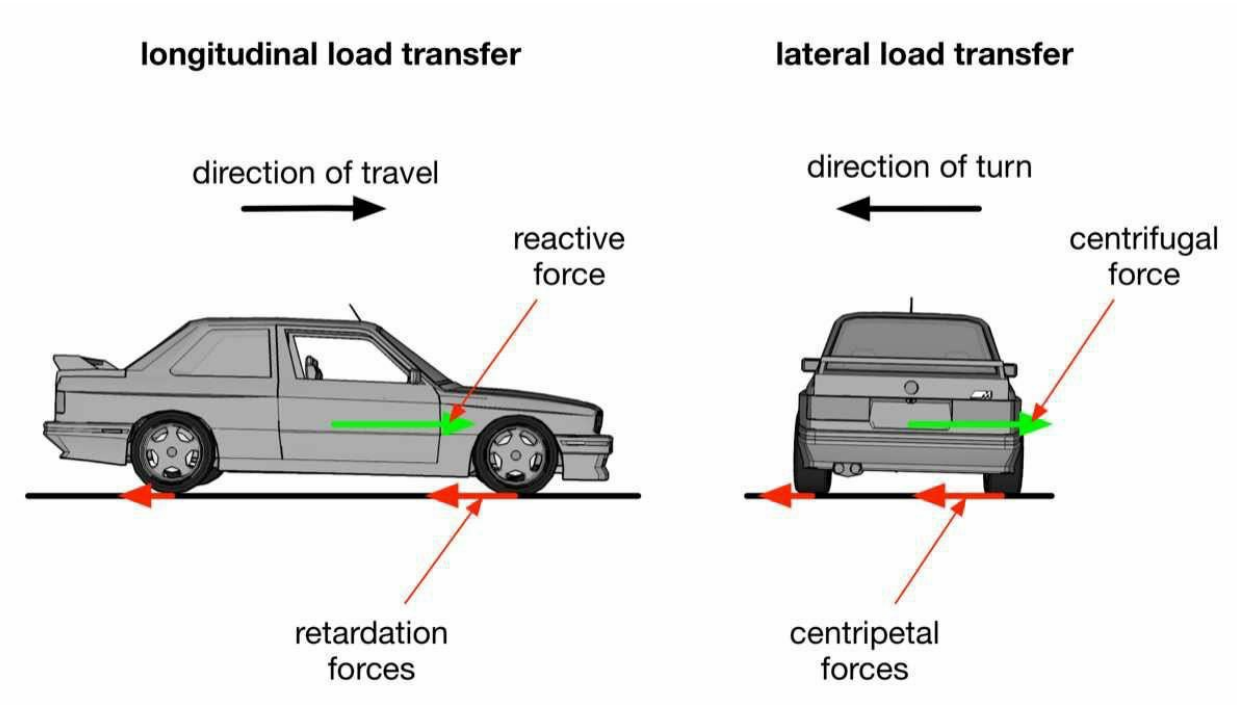
performance-related concepts

Before we discuss set-up in detail, I must explain the following concepts related to race car dynamics: load transfer, tyre slip angle, and tyre traction circle. These concepts do not fit well in the discussion of the car feel, because they are physical characteristics of the car. But they also do not belong in the description of the components, since many components affect them. And you need to understand them, before you learn to set up a race car. So, here is as good a place as any to explain these concepts.

load transfer

During cornering, the car is kept on track by the centripetal forces acting through the centres of the tyre contact patches. Each centripetal force induces an equal and opposite Newtonian counterpart, a reactive centrifugal force, that acts through the centre of gravity (CG) of the car body, and pushes the body outward. The coupling between the centripetal force and its counterpart pushes the body onto the outside wheels, resulting in lateral load transfer. Higher ride height raises the CG. A higher CG lengthens the moment arm that couples these opposing forces, thus amplifying their effect on body roll and increasing the load transferred onto the outside wheels.

A related concept is longitudinal load transfer, which refers either to the forward load transfer during corner entry deceleration, or the rearward load transfer during corner exit acceleration. Forward load transfer causes the car to nosedive onto its front wheels, and the rearward load transfer causes the car to squat onto its rear wheels. The two actors that perpetrate longitudinal load transfer are the tyres' drag forces and the body's forward momentum. See the figure below.



In most situations, these two types of load transfer conspire to cause mischief upon the suspension geometry. And there is no way to prevent load transfer. All that we can do is to reduce its effect using a good set-up and a collection of proper driving techniques.

In real life, little things like a centimetre higher ride height can have a noticeable impact on the performance and the feel of the car. In a lightweight, low-power car, even the weight of the driver, the side of the car on which he sits, and the height of his seat will affect the handling. So, on a track where right-hand turns predominate, a right-hand drive car is preferable, because during right turns the driver's weight counteracts the car body's tendency to lean onto the left side wheels. I doubt S2U takes the driver's weight into consideration, but this is a fact you need to be aware of in real life.

Overly soft suspension cannot resist body movement. Then, an excess amount of load transfer occurs during a manoeuvre, and the suspension can no longer keep the laden, outside wheels upright. This reduces the tyre contact patch areas of the outside wheels, which in turn reduces their traction. A stiff suspension resists load transfer better, thereby minimising the outside wheels' traction loss. But if the suspension is too stiff, it loses compliance, and the wheels behave as though they are bolted directly onto the chassis, so they can no longer maintain contact with the track surface. This also results in traction loss. So, it is vital that you find the optimum suspension set-up for the track.

Load transfer affects car behaviour in yet another way by interacting with the arrangement of the drivewheels. On a rear wheel drive (RWD) car, the traction capacity of the rear drivewheels' tyres is split between centripetal force and forward thrust, during corner exit acceleration. Acceleration causes weight to be transferred to the rear. This added load presses the rear tyres down onto the track surface, thereby increasing their traction capacity. This is a good thing. During corner entry braking, the rear tyres' traction capacity is apportioned between generating centripetal force and drag. Similarly, the front tyres' traction capacity is apportioned between centripetal force and drag, during corner entry. When exiting the corner, however, the front tyres' traction capacity is reduced by the rearward load transfer. The remaining traction capacity is used to generate centripetal force needed to complete the turn. This slight reduction in the front tyres' traction capacity is of little consequence, since the rear wheels are doing most of the work in this phase of cornering.

On a front wheel drive (FWD) car, the corner exit dynamics are quite different, although the corner entry dynamics are similar to those of RWD cars. As the FWD car exits the corner and transitions from neutral throttle to acceleration, the load transfers to the rear. As a result, the front tyres become unloaded, and they lose some of their traction capacity, just when it is needed the most. Moreover, the remaining traction capacity of the front tyres must be split between forward thrust and centripetal force. The result is corner exit understeer. Understeer is unpleasant.

There is another malady that FWD cars suffer. It is called the torque steer. Under heavy acceleration out of a corner, the tyres of the two front drivewheels possess different amounts of traction capacity, so the two wheels accept difference amounts of engine torque. This difference in torque is transmitted back to the steering wheel, and the driver can feel that the steering pulls itself to one side. Torque steer, too, is unpleasant.

Both the understeer and the torque steer can be mitigated to a degree by tuning, but even the cleverest of boffins in the paddock are subject to the laws of physics. So, I, like many, prefer RWD race cars. I shall now summarise load transfer and tyre traction capacity dynamics.

RWD Car Cornering:

- Deceleration (corner entry):
  - front wheels become loaded; front tyres generate centripetal force and drag
  - rear wheels become unloaded; rear tyres generate centripetal force and drag
- Acceleration (corner exit):
  - front wheels become unloaded; front tyres generate centripetal force only
  - rear wheels become loaded; rear tyres generate centripetal force and thrust (good acceleration)

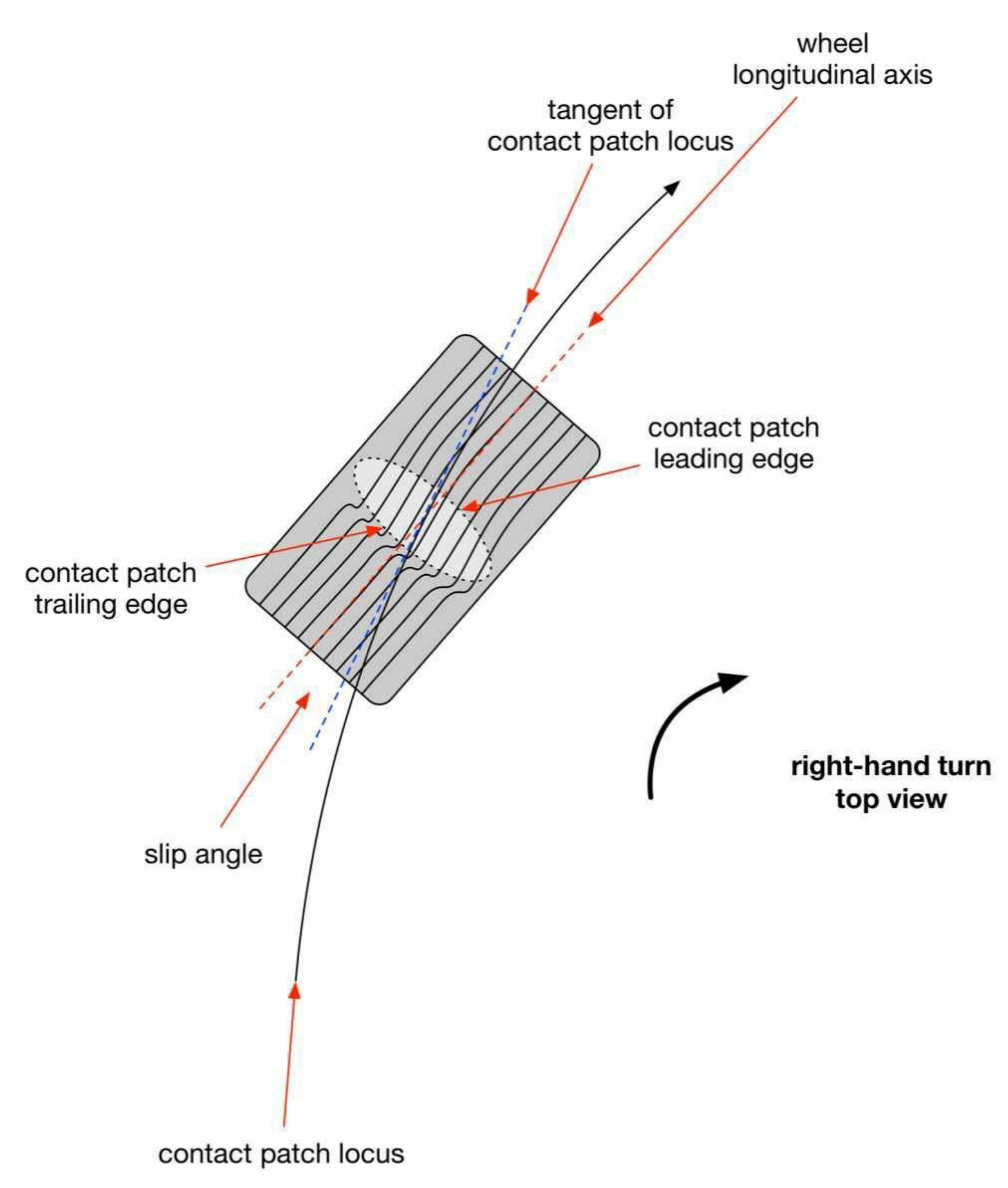
FWD Car Cornering:

- Deceleration (corner entry):
  - front wheels become loaded; front tyres generate centripetal force and drag
  - rear wheels become unloaded; rear tyres generate centripetal force and drag
- Acceleration (corner exit):
  - front wheels become unloaded; front tyres generate centripetal force and thrust (poor acceleration, understeer, torque steer)
  - rear wheels become loaded; rear tyres generate centripetal force only

tyre slip angle

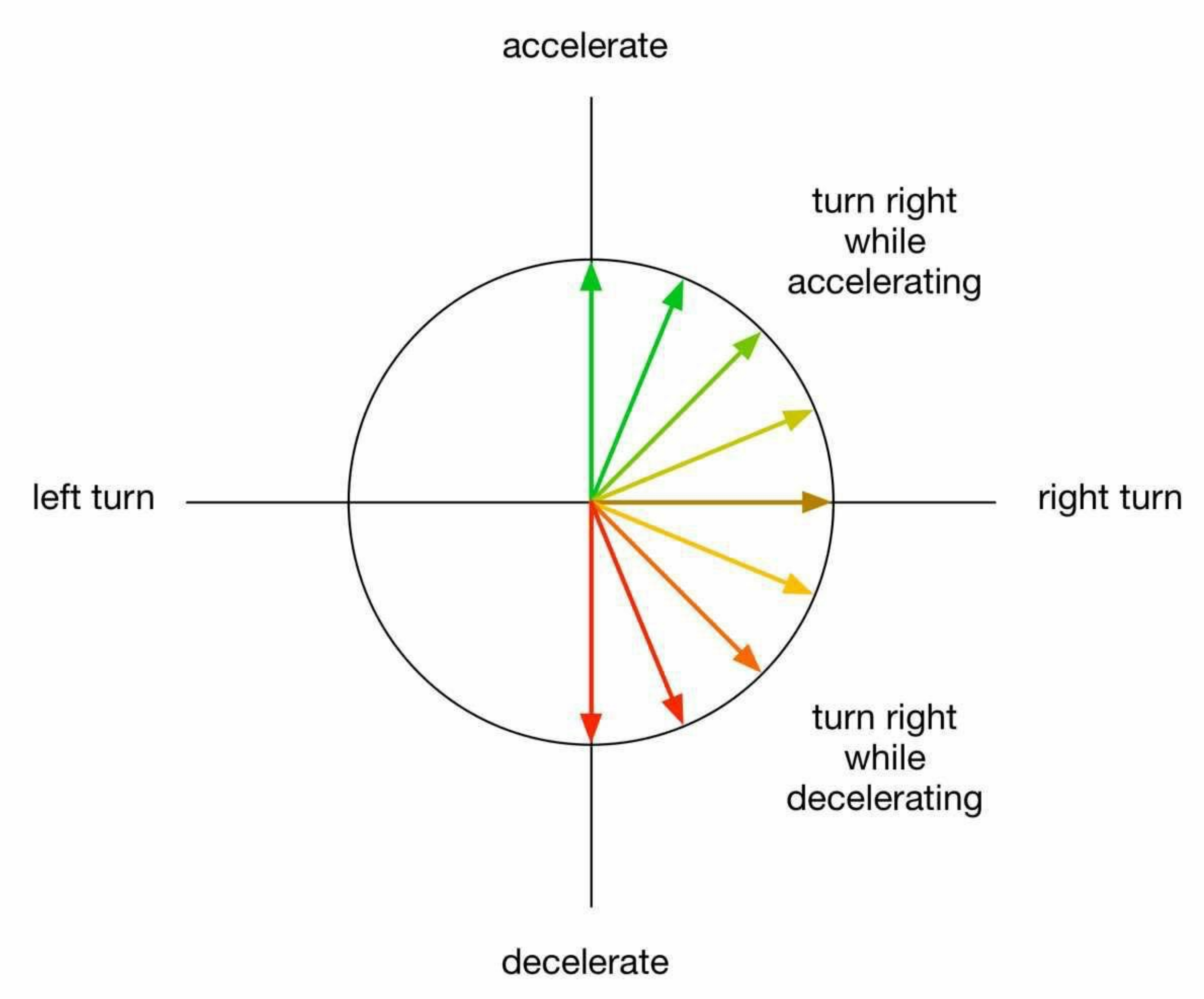
The rubber tyre is elastic and sticky. During cornering, the metal wheel rim points into the corner, but the rubber tread lags behind slightly, because the tread adheres to the track surface. Both the tread and the sidewalls of the tyre elastically deform, in response. The tyre slip angle is the angle between the wheel centre line and the tangent of the tyre contact patch locus (tyre’s path on the track surface).

Up to a limit, the greater the slip angle, the greater the centripetal force the tyre generates, and thus the greater the tyre’s cornering ability. But when the tyre tread is deformed beyond its elastic limit, the tyre begins to lose its adhesion. Good racing tyres tolerate large slip angles, up to about 10 degrees, and they give ample warning to the driver before losing traction. Street tyres tolerate much smaller range of slip angles.



tyre traction circle

If we plot the tyre's thrust or drag force on the *y*-axis against the left or right centripetal force on the *x*-axis as the car goes through a sequence of left- and right-turn corners, the resultant vector traces out (*x*, *y*) points that approximate a circle, as shown below. The harder the acceleration or braking, the farther along the *y*-axis the point reaches. And the harder the cornering, the farther along the *x*-axis the point stretches. Only the best of drivers under ideal conditions can carve out a near-perfect tyre traction circle. The rest of us mere mortals scratch out something resembling a blunted diamond. Nevertheless, this diagram is called the traction circle.



Keep these concepts in mind, when you feel the urge to manhandle the car. Imagine the pain you are inflicting upon the innocent tyres, every time you stand on the brake pedal, mash the accelerator pedal, or wring the steering wheel. Be kind to your car, and it will take you far.

setting up the car

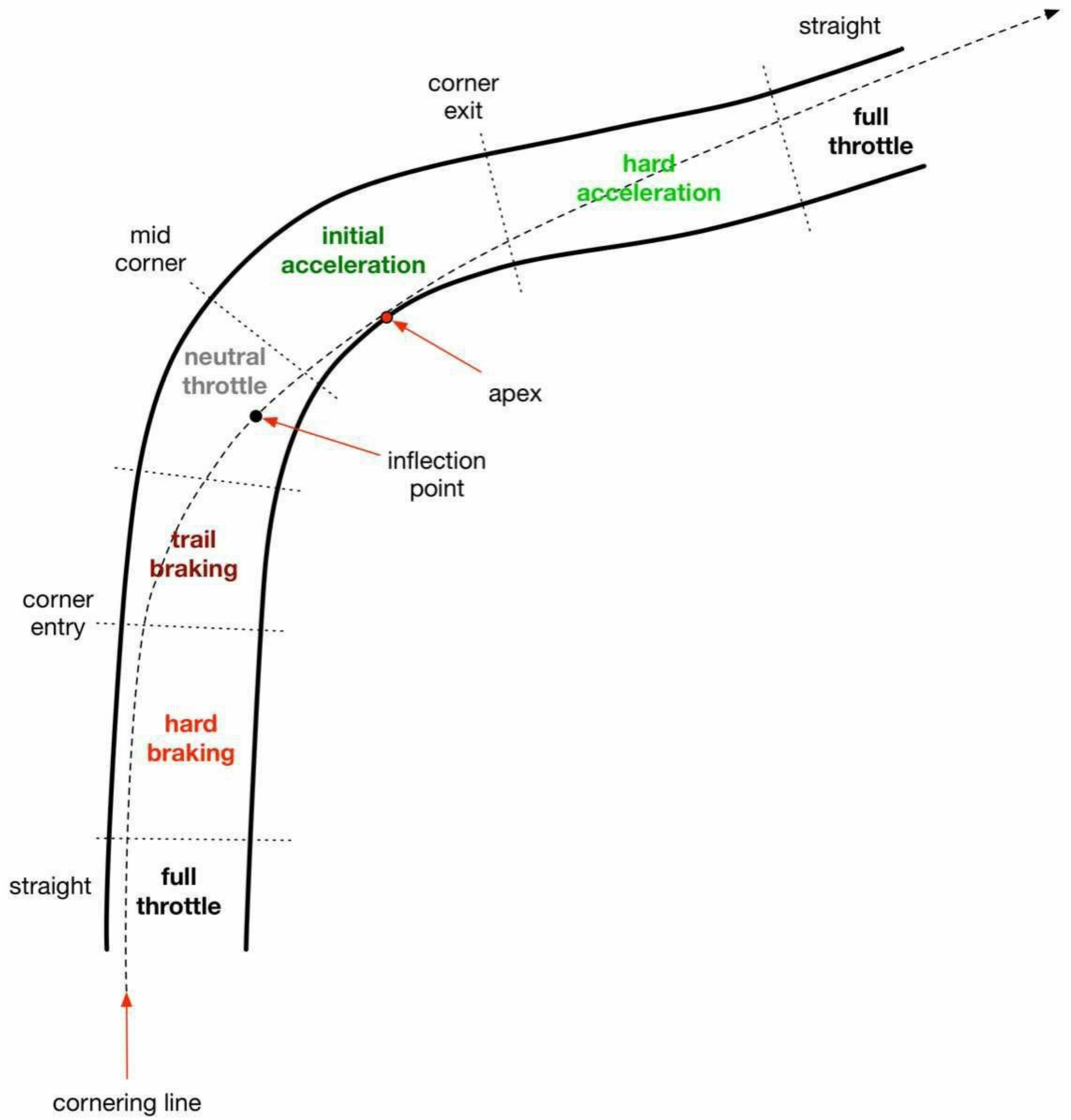
Now that you understand the race car components and race car dynamics, we can discuss race car set-up: adjusting race car components to alter race car dynamics. But at this point, you have a dilemma. You need in install adjustable, racing components on your car first, before you can tune them. But you have only a stock road-going M3 that lacks adjustable components, because you have no funds to purchase the upgrade parts.

I suggest that you skip the remainder of this chapter, familiarise yourself with the driving techniques I present in the next chapter, and learn to drive The Ring in your stock M3. While learning, drive every lap in a rigged race against zero opponents, as I described earlier. Anticipate the corners ahead, take the proper line through each corner, stay on the track, do not bang into the Armco, and most importantly complete the race. Once you have won several of these one-man, rigged races, you will have earned XPs sufficient to reach the next experience level. When you reach the next level, you will have earned a large enough purse to purchase the upgrade components for your M3. You may then return to this chapter and study car tuning.

Setting up a car in real life begins with the driver running a few laps to get the feel for the car in its initial set-up that the race car engineer believes is a good starting point for the track. When the driver returns to the pits, he describes how the car is misbehaving on track. And drivers always complain about their cars. The engineer listens to the driver's vague complaints, as his attention drifts ever so gradually to the on-board telemetry data collected during the installation lap. When the driver has had his say, the engineer breathes out a familiar sigh, says a quiet prayer, and attempts to understand what the car is actually doing on the track by assimilating the telemetry, weather, set-up sheets from previous outings, driver feedback, and divine guidance. Once the engineer has identified the car's misbehaviour and has devised a potential cure, the mechanics replace or adjust the relevant components.

Some adjustments, like the wing angle, may take but a few seconds to adjust. Others, like changing the spring stiffness, will take greater time and effort. When the mechanics are done, the driver hops back in for another few laps, returns to the pit, and lodges another round of complaints. Ideally, this process should repeat, until everyone concerned is happy with the set-up. In reality, time, money, or patience runs out, well before everyone is satisfied. Fortunately, the task of setting up the car is much easier on a simulator.

I shall now explain car set-up from the driver-centric perspective in the following phases of driving: full throttle, hard braking, trail braking, neutral throttle, initial acceleration, and hard acceleration. Although it is convenient to use these phases in discussing car behaviour and driving techniques, they are not so rigidly ordered in practice. In some corners for example, you may immediately return to throttle from trail braking, thus shrinking the neutral throttle phase to a few milliseconds. In the next chapter, we will structure our discussion of the driving techniques according to these phases, as well. Our focus at the moment is on how to set up the car so as to improve its handling and performance through each phase.



To start the set-up process, purchase the upgrade parts I mentioned earlier. Then, initialise the car set-up to the factory settings as follows: from the **Garage** menu in the main screen, enter the **Tune** screen and select the **Create** menu item. Having initialised the set-up, you should drive the car a lap on the track. To do that, press the **Back** button to return to the **Garage** menu, and select the **Test** menu item. Then, enter the Nordschleife track. You will find yourself sitting at the start line in your E30 M3, with the engines running.

Your upgraded M3 is no longer that anaemic buckboard that you drove while learning The Ring; it is now a proper race car that can be tuned to the fullest. But before you tune the car, you must know the baseline behaviour of your car, and identify the characteristics you wish to modify in order to suit the track and your driving style. So, you must test drive at least a few laps, to get the feel of your car in its factory set-up.

Here is a top tip. To get better acquainted with an unfamiliar car, start by driving a couple of laps in the factory set-up. Next, select the softest anti-sway bars, springs, and dampers, and drive a few more laps. Then, stiffen the anti-sway bars, springs, and dampers to their maximum values, and test drive again. During this little exercise, you will become familiar with the full range of the car's behaviour. Once have gained some racing experience, though, you will no longer need to perform this ritual for every new car.

At this stage, you should already have learnt the track, thoroughly. Do not attempt to tune the car, while you are still learning the track. If you do, you would not be able to tell whether the lap time improvements came from your becoming more familiar with the track or from the adjustments you made to the car.

full throttle phase

When barrelling down the straight at full throttle, the key issue is straight-line stability of the car.

Vague steering: A vague steering is not necessarily caused by an improper steering geometry. Because the only tactile feedback the simulator can provide is through the force feedback steering wheel, slow damper settings that are too soft to resist body roll may feel like a vague steering. Overly soft anti-sway bars may feel the same. So, tweak the suspension first, before you muck about with the steering geometry.

- Stiffen the *slow jounce damper* and the *slow droop damper* at both ends of the car by equal amounts. Avoid altering the balance of the car by making opposite adjustments between the front and the rear ends. Also, do not stiffen these components too far beyond their midpoints.
- If these adjustments do not cure the vagueness, you may need to play with the steering geometry, as described next.

Wandering on straights: Some cars wander on the straights like Rocinante, Don Quixote's scraggy steed. Stiffening the dampers may be insufficient to fix this problem. Make the following adjustments for better straight-line stability.

- Raise the positive *castor angle*. The increased castor angle improves the steering mechanism's self-centring tendency.
- Give a bit more *front toe in*. Because the two front wheels point inward, they tend to steady each other as they roll along a straight line. But this straight-line stability will worsen cornering understeer.

Skipping over bumps: If the car skips over the bumps and lose traction, soften the *fast jounce damper* and the *fast droop damper* at both ends of the car. If the fast jounce dampers are too stiff, the wheel will not be able to move up to absorb the bumps. If the fast droop dampers are too stiff, the wheel will not be able to return quickly back to its original position after cresting a bump, and jams itself inside the wheel well after a series of bumps, thereby robbing the suspension of its compliance.

hard braking phase

At the end of the straight just before entering the corner, you are hard on the brake to slow down for the corner. In this situation, the main issues are wheel lock-up, stability, compliance, and cornering gear.

Wheel lock-up: You can mitigate wheel lock-up by adjusting the brake pressure and the brake bias. The most important thing though is to learn to modulate the force you apply to the brake pedal. And you must be equally adept in using the brake pedal with either foot.

- The *brake pressure* should be set so that the brake pedal has the most range between brake engagement and wheel lock-up. I find that the midpoint works for most cars in S2U.
- Set the *brake bias* so that when you are braking hard at the end of a long straight, the front wheels lock up moments before the rear ones. Under hard braking, the body load transfers to the front, so the lightly loaded rear wheels will lock up before the front, if the front and the rear brakes receive equal brake pressures, resulting in corner entry oversteer. When braking downhill, the rears will lock up even earlier. Start with the bias

somewhere around 55:45, in favour of the front.

- If you want to find the precise point of wheel lockup, go to a straight, flat track with Monza, accelerate up to top speed along the front straight and slam hard on the brake pedal, before you reach the first chicane. Keep the car on a straight path; do not turn into the corner. At some point, the wheels will lock up. Once the car stops, enter the instant replay, rewind to the point just before you slammed on the brake pedal. Change the view to an external camera that shows the car from the side, so that you can observe the onset of wheel lockup. Note which wheels —the fronts or the rears—lock up first. Return to the car set-up screen. If the rear wheels locked up first during the test, slide the brake bias toward the front by one click. Repeat the test, until the fronts and the rears lock up at about the same time. Now, slide the brake bias to the front by one more click. This is the ideal bias setting at which the brakes are the most efficient, when braking on a straight, flat piece of track. It probably will not work in all the corners on the track. That compromise brake bias setting lies somewhere farther toward the front than the ideal setting. So, it is good to know the ideal brake bias setting of your car.

Stability: Stability under hard braking is achieved by adjusting the ride height, springs, and dampers.

- Lowering the *ride height* lowers the centre of gravity (CG), which reduces the amount of rear-to-front load transfer, which improves handling. But do not lower the ride height too much, or the front of the chassis will scrape the ground under hard braking. You will then lose all control at the front. The problem is worse, if the braking zone is bumpy.
- Stiffer *springs* will better resist load transfer. If the car nosedives under hard braking, stiffen all the springs by one click, thereby preserving the balance.
- If you stiffen the springs to limit nosedive, you will also need to stiffen the *slow jounce damper* and the *slow droop damper* at both ends of the car.
- Note that lateral (left-right) load transfer is controlled with springs, dampers, and anti-sway bars, but the longitudinal (front-rear) load

transfer is controlled only with springs and dampers. I know of no consumer-grade simulators that implement anti-squat and anti-dive suspension components.

Compliance: Adjust for compliance as described in trail braking, below. In general, softer suspension set-up offers more compliance.

Cornering Gear: Shifting, either down or up, mid corner not only robs time, it also unsettles the car at a critical moment as it tiptoes past the apex. It is better to traverse the entire corner—from the entry to the exit—in one gear. Fortunately, it is possible to do this in a majority of corners on most tracks.

- The *gear ratio* should be short enough to accelerate out of the corner, yet long enough to not reach the engine rev limit, mid corner.
- If two adjacent corners are close enough together and they both can be traversed in the same gear, you may wish to lengthen the gear ratio just enough so that the short straight between the two corners may be covered in the same gear, without over stressing the engine. But if you lengthen the gear ratio too much, the gear will no longer be suited to the corner. This will cost you cornering time.

trail braking phase

Race driving schools often teach student racers to do all the braking in a straight line, then to enter the corner. This textbook approach is too conservative. In practice, you will still be braking, as you begin turning into the corner. I will describe this driving technique, called trail braking, in the next chapter. Here, I will focus on the set-up issues of manoeuvrability, balance, and compliance. These are competing demands on the suspension, so it is sometimes difficult to achieve a set-up that fulfils all of them. When setting up the car, adjust for manoeuvrability first, then fine tune for balance. Tweak for compliance last.

Manoeuvrability: The anti-sway bars, springs, dampers, differential, camber, and toe affect manoeuvrability. So, be systematic with your adjustments. Make a small adjustment to one component. Test drive. Then, based on your driving test, undo the adjustment or try another adjustment. Remember that manoeuvrability comes at the cost of compliance.

- If the car falls over onto the outside wheels as it enters the corner, stiffen both the *anti-sway bars* a bit. On the other hand, if the car feels too skittish while cornering, then soften the anti-sway bars.
- If, after adjusting the anti-sway bars a few clicks away from the middle setting, the car still misbehaves, adjust the four *springs*, instead of straying to the far ends of the anti-sway bar range. Stiffer springs make the car feel more manoeuvrable. If you go too stiff, though, the car will feel skittish and the manoeuvrability will decrease.
- Stiffer springs require stiffer dampers, and vice versa. So, adjust the four slow damper settings in lockstep with the springs. Collectively stiffen or soften the *slow jounce damper* and the *slow droop damper*.
- If the car understeers into the corner as you come off the throttle, it is likely caused by the two rear drivewheels being locked together too tightly while coasting. Coasting is when you are completely off the throttle, but the engine is still under load because you are still in gear. To cure the power-off understeer, reduce the LSD's *coast side (deceleration) lock* amount. In contrast, if the car oversteers as you come off the power, increase the coast side lock value.
- There is another, perhaps more common, cause for corner entry understeer: entering the corner with an excess speed. There is no mechanical cure for this, since the fault is not with the car but with the driver. But you can eliminate the excess-speed understeer by entering the corner at a proper speed. To find the right speed for the corner, start by taking the corner at a slower speed than that which your instinct would allow. If you can go through the corner without any drama at that speed, then increase the speed by a small increment and drive through the same corner again. Gradually raise the cornering speed, until you begin to feel the onset of understeer. The speed just shy of the last run is the proper cornering speed. Do not confuse the excess-speed understeer with the power-off understeer. They both occur at the same spot in the corner and they both feel the same to the driver. But their causes are different.
- Set the *wheel camber* to a couple of clicks on the negative side to improve traction during hard cornering. Body roll during cornering causes the outside wheels to transition from negative camber to upright posture, thus improving their tyres' traction. Give the front wheels more negative camber than the rears, because when entering a corner, the

outside front wheel must remain upright under the combined load of forward load transfer and cornering force. In general, avoid positive camber.

- Increase the *front wheel toe out* by a tiny amount to increase the cornering ability and to cure a minor understeer. The side effect is the reduction in straight-line stability.
- Increasing the *rear wheel toe out*, too, will improve the cornering ability. But be very careful with it. A little too much of it will yield a massive oversteer in a corner. And even while travelling along a straight, the rear end will seem too impatient to overtake the front end. Most race cars employ a spot of *rear wheel toe in*.

Balance: The brake bias, tyre pressures, anti-sway bars, springs, and dampers may be set differently between the front and the rear to affect the handling of the car—its oversteer-understeer balance. The end of the car with stiffer suspension settings loses traction before the softer end. Hence, a relatively stiffer front (softer rear) will induce understeer, and relatively softer front (stiffer rear) will induce oversteer. Be sure to make small adjustments, when tweaking for balance.

- Ensure that the *brake bias* is right for the majority of the corners on the track. The rears should not lock up before the fronts, or you will have a car that pirouettes beautifully into corners but cannot do much else. Brake bias is not so fine a mechanism as to be used as one of the primary balance controls. But it may be used, in a pinch, to cure a chronic understeer during a race, by sliding the in-cockpit brake bias adjustment lever more toward the rear. Do the reverse to mitigate oversteer. Note that even if you began the race in a well-balanced car, because as you burn off fuel and tyres, the car's balance will certainly change. In long races, use the in-cockpit brake bias adjustment lever to rein the errant car back into balance.
- A simple and often effective balance control is offsetting the front and the rear *tyre pressures*. To reduce understeer, set the front tyre pressures a click or two lower than the rears. Do the opposite to reduce oversteer. Remember, though, that overinflating or underinflating the tyres will undo all your hard work. So, be judicious.
- If the tyre pressure trick does not work, make offset adjustments to the

front and the rear *anti-sway bars*. Softer fronts cure understeer, and softer rears cure oversteer. If you make the anti-sway bars too soft, the car will fall over onto the outside wheels when entering a corner. If too stiff, all four wheels will skid while cornering.

- If the handling is still unsatisfactory, make offset adjustments to the front and the rear *springs*. Softer fronts (or stiffer rears) reduce understeer, and softer rears (or stiffer fronts) reduce oversteer.
- If you did adjust the springs by a significant amount, adjust the dampers, too. In general, stiffer springs require stiffer dampers, and softer springs require softer dampers. I think of the springs as coarse adjustments and the dampers as fine adjustments. So, start by finding the spring rates that offer a decent balance through the corner. Then, refine the car's corner entry balance using the dampers as follows:
    - Corner entry balance may be affected by making offset adjustments to the front and the rear *slow dampers*. Slow dampers resist body movement. Softer slow dampers allow more body movement, and stiffer slow dampers allow less body movement.
    - Sudden and excessive body movement deranges the laden suspension, which makes it impossible for the suspension components to keep the tyre perpendicular to the road surface. This shrinks the tyre's contact patch, and reduces traction at that corner of the car. If the car body is collapsing onto the outside front wheel during corner entry, stiffen the front slow jounce dampers. Of course, you will have to accept a touch of corner entry understeer.
    - If the car understeers during corner entry, soften the front slow jounce dampers or stiffen the rear slow droop dampers. Both adjustments give the same result, because they both make the front tyres adhere to track surface more than the rear tyres. On the other hand, if the car oversteers when entering a corner, make the opposite adjustments.
    - If the corner entry is bumpy and the car oversteers or understeers over bumps, make offset adjustments to the front and the rear *fast dampers*.

Compliance: Compliance is affected by the stiffness of the suspension components and the tyre pressures. In chasing compliance, it is better to focus on fine-tuning the dampers, instead of meddling with the anti-sway bars and the springs, lest you unintentionally disturb the balance and manoeuvrability already achieved. Stiff suspension gives the driver a better feel of what the car is doing. But stiff suspension is less compliant, and gives a harsher ride. Drivers would countenance a harsh ride with equanimity, if it means the car would handle well. But overly stiff suspension loses its compliance, and makes the car skittish.

- If the car floats over bumps like a rocking boat, stiffen the *fast jounce damper* and the *fast droop damper* at both ends of the car. If the car is too intransigent and skips over the tops of the bumps, soften the fast dampers.

neutral throttle phase

In mid corner, your main goal is to settle the car on a smooth curve that intersects the apex and the corner exit points. Speaking pedantically, you should be in neutral throttle as you clip the apex. Neutral throttle is when the throttle is held partially open with a cornering gear engaged so that the engine is under a constant load, but is neither accelerating nor decelerating. But there are many corner types in which you may be back on the throttle, well before you reach the apex. We will discuss cornering techniques in the next chapter. Here, the key issues are manoeuvrability, balance, and compliance, which are adjusted in the same way as they are for trail braking. The only difference is in the way the LSD affects the car's mid corner balance. In the neutral throttle phase, the LSD *preload* value is at play, but not its coast side value. Raising the preload value increases understeer, and lowering the preload value increases oversteer.

initial acceleration phase

Once you have clipped the apex, you want to return to full throttle quickly and smoothly. The issues in this phase are responsiveness and stability.

Responsiveness: The drivetrain adjustments that affect responsiveness are the differential and the rear camber. The rear tyre pressures also play a role, but to a lesser degree.

- If your car suffers from power-on oversteer, try raising the LSD's *power* *side lock (acceleration)* to increase the lock between the two rear drivewheels, thus increasing their overall traction. Note that this increase in rear traction also brings on more understeer.

- There is another, more common, type of power-on oversteer. It is caused by the driver stomping on the throttle, thereby delivering a surge of power to the rear wheels and breaking loose their tyres. When the car is in a precarious state such as this, the driver needs to be gentle on the pedals. Do not confuse the driver-induced power-on oversteer with the one caused by a lack of rear-end traction. Although both types of oversteer occur at the same spot in the corner—that is, when the driver comes back on the throttle—their causes are different.
- The *rear camber* is set slightly on the negative side, so that when the car's load transfers to the rear under acceleration, the rear wheels become upright, thus providing more traction.
- Reducing the *rear tyre pressures* by a click or two improves the tyres' compliance, and produces more traction at the rear. This tends to reduce power-on oversteer.

Stability: The stability during initial acceleration is affected by the rear toe angle.

- Increase the *rear toe in* for a more stable acceleration. Too much rear toe in will cause the car to understeer upon throttle application.

hard acceleration phase

Once you are on the exit line, your goal is to reach the top speed, as soon as maybe. In this case, too, the issues are responsiveness, stability, and balance.

Responsiveness: Here, the responsiveness is affected by the final drive ratio and the individual gear ratios.

- The *final drive ratio* alters all the ratios collectively. Start by setting the final drive ratio so that the car reaches top speed on the longest straight and the engine reaches redline at the end of the straight, in a given aerodynamic configuration.
- Set the *individual gear ratios* so that they give quick acceleration out of a particular corner, yet still have long enough legs to get up to speed

without over revving the engine.

Stability: Try the same accelerative stability adjustments here as in the initial acceleration phase.

Balance: Adjust the tyre pressures, anti-sway bars, springs, and dampers in offset fashion just as you did for the corner entry balance, but in the opposite manner. For example, if your car understeers during corner exit hard acceleration, the front tyres are losing traction before the rears. This may be caused by the overly stiff front slow droop dampers, which are lifting the front tyres off the track, as the nose of the car rises under acceleration. If, on the other hand, your car oversteers during corner exit, the rear springs and dampers are probably too stiff relative to those at the front. Make offset adjustments to the front and the rear tyre pressures, anti-sway bars, springs, and dampers to cure the specific ill.

telemetry

Phew, that was a rather lengthy discussion of car set-up. I vacillated over whether to provide you with my set-up for the race-modified E30 M3. I decided against it, eventually. Everyone has a unique driving style. So, the set-up that works for me may not work for you at all, and may only serve to confuse you. The proper thing for you to do is to upgrade your M3 with the racing components, and use the factory set-up as your starting point.

Adjusting a single component can affect the behaviour of the car in multiple ways. So, be systematic, when setting up a car. Alter the setting of one component by a small amount, test drive, evaluate the behavioural changes of the car, take copious notes, and repeat until your lap times stabilise. At least on a simulator, we do not have to take into consideration the weather, traffic, fatigue, funds, and other vagaries of life.

All good PC-based simulators provide telemetry data analysis tools by which you may evaluate how well you and your car performed on track. Even GT5 provides a basic charting tool. But S2U does not. Marks for GT5, yeah?

What S2U does provide is the instantaneous telemetry data overlay, which you can use when viewing a replay of your lap. To analyse your performance, drive a lap, view the replay video, then press the **Cycle HUD**

Mode button a few times until you reach the telemetry view. This view provides the instantaneous values of the gear, RPM, lateral G load, pedal input levels, etc.

Perhaps the most useful gadgets in this lot are the four circles overlaid atop the tyre symbols. The radius of the circle represents the amount of *instantaneous suspension load* at that corner of the car. The radial line inside the circle points outward from the centre along the direction of the *centripetal force*. The colour of the circle's rim represents the *instantaneous tyre friction* (green is high traction and red is low traction). The flickering number under the tyre symbol indicates the *instantaneous tyre temperature* as a percentage of peak temperature the tyre is designed to tolerate.

One of the important goals of car set-up is to run the tyres in their Goldilocks operating temperature range—neither too hot nor too cool. S2U, like other simulators, shows the *outer*, *middle*, and *inner cumulative tyre tread temperatures* (blue is cold and red is hot) as three vertical bands of colour inside the tyre symbol. This temperature information makes it easy to fine-tune the wheel camber and tyre pressure. An excessive negative camber will raise the inside tread temperature after several kilometres of driving. Over inflated tyre will have higher middle tread temperature. Under inflated tyre will have higher outer and inner tread temperatures. What we want is to set the car up so that the outer, middle, and inner tyre tread temperatures are about the same, all hovering in the pale green zone, throughout the race.

Tyre temperature information also aids in refining balance. If the tyres at one end of the car get much hotter than the other end, then too much weight is being transferred to that end. Stiffen the suspension at that end a bit or soften the other end, in order to control load transfer. But take care not to alter the car's balance significantly, when you make a front-rear offset adjustment like this.

Study the telemetry, in conjunction with the in-car and the on-track cameras, to evaluate how well the driver-car package performs on track. Then, adjust the car and your driving style, based on your evaluations.

In the next chapter, I present various driving techniques—making the car behave the way you want using nothing but your hands and feet.

CHAPTER FOUR — DRIVING TECHNIQUES

overview

Race car driving is a bit like jazz drumming. Both activities require a keen mind, deep concentration, good situational awareness, impeccable sense of timing, excellent hearing, deft touch, and quick reflexes. Both depend on four-way independence of the limbs. And both employ a technique called the heel-and-toe.

Driving properly means extracting the most performance out of the race car, while conserving the resources like fuel, brakes, and tyres, as well as prolonging the service lives of the engine and the drivetrain. For the most part, performance equates to tyre traction. As such, many driving techniques described herein deal with maximising tyre traction capacity under the ever-changing circumstances, using only the steering wheel, the gear shifter, and the foot pedals, with occasional assistance from the handbrake lever and the brake bias lever.

A description of driving techniques must address both the optimal and the suboptimal conditions. Under optimal conditions, the car is properly set up to suit the track's peculiarities and the driver's propensities. However, a set-up that works perfectly at the start of the race can turn downright nasty just a few laps in, due to factors that are beyond the control of the engineers and the driver. Hence, a discussion of driving techniques must inevitably include tricks for coping with improper set-up, taming an ill-tempered car, recovering from a loss of control, braking on a downhill slope, tiptoeing round adversely cambered corners, racing in the rain, etc. And of course, no discussion of race driving is complete, unless it covers strategy (tyre choice, fuel quantity, number of pit stops, weather contingency, etc.) and tactics (navigating through slower traffic, fending off motivated opponents, exploiting their weaknesses, using track layout and ground topography against them, etc.).

I start off this chapter with a high-level description of the racing rules. Next, I describe several mental and physical techniques. Then, I cover corner types, cornering techniques for the various types of corners, race strategies, on-track tactics, and specialised driving techniques.

Before we continue, I suggest you visit the site *You Suck At Racing* by Professor Ian Korf, who teaches bioinformatics at UC Davis. He is an experienced racer, both on the track and on the simulator, and his writing is focused, organised, and crisp. Throughout the site, there are plenty of valuable insights on safety and on improving one's racing skills in a methodical, quantifiable way. The how-to section provides useful tips on building a simulator rig. The library section gives a good selection of reading material. There are also several in-car videos from which you can learn.

Now, let us begin.

racing rules

All officially sanctioned race events, be they amateur or professional, are conducted under the auspices of a governing body. F1, GT, and WRC races worldwide are governed by the Fédération Internationale de l'Automobile (FIA). In the US, road and rally races are governed by the Sports Car Club of America (SCCA), and oval stock car races are governed by the National Association for Stock Car Auto Racing (NASCAR). These governing bodies promulgate racing rules and technical regulations for each form of racing. They also establish the processes by which infringers are prosecuted and punished. On-track mischief is immediately investigated and punished with drive-through penalty, timed penalty, or disqualification. More serious rule infringements, such as the use of prohibited technologies or banned fuel additives, the governing body gives the team a notice of process. The team has certain due process rights such as legal representation, the right to be heard at a tribunal, and the right to appeal an adverse ruling. Punishments include warning, fine, disqualification, points forfeiture, and race ban. In many ways, these private organisations function like government administrative agencies, and they take their rules and regulations as seriously as does the government does its laws. What is the difference between a law, a rule, and a regulation? You need not know, because this titbit will not make you go faster. But if you are curious, go to law school.

S2U ensures that our race cars always comply with the technical regulations of the appropriate racing series. So, we need to know only the flag rules and a few relevant racing rules.

In the old days when there were no on-board radios and computerised timing and scoring systems, drivers receive information from their teams on pit boards when they pass by the pits straight, and they receive instructions from the flag marshals who are posted throughout the track. Today, despite the advent of radios, cockpit displays, and automated on-track warning lights, pit boards and flags are still in use as a backup system. The following is a list of racing flags:

- Green: race start
- Red-and-Yellow: caution at a corner; debris or fluids
- Yellow: caution part of track; slow down, no overtaking
- Double Yellow: caution entire track; slow down, no overtaking
- SC: caution entire track; follow the safety car, no overtaking
- Blue: a lapped car should move aside to let the leaders pass
- Black: driver disqualified; return to pit
- Red: race stopped; severe weather or serious accident
- White: final lap
- Chequered: race end

mind and body

Although mental conditioning and physical training are not driving techniques per se, they form the foundation upon which proper driving techniques are built. So, let us spend a moment talking about them.

Mental: As you slot into position at the starting grid on your first race, no matter whether it is on the simulator or in real life, you will feel your heart revving at a higher rate than your engine, and your hands shaking like a leaf in the wind. It is the physiological manifestation of the *fight-or-flight response*. Be not alarmed; it is normal. Your brain released a dose of adrenaline in your bloodstream, which sharpens your senses, and primes your body for the drop of the green flag. A short, ten-lap race round a typical track can take 20 or 30 minutes. Even on a living room simulator, it can be mentally and physically demanding.

A stressed mind causes the body to tense up. Tension causes discomfort. Discomfort causes distraction. Distraction can lead to death. It is imperative that you learn to calm your mind, when racing. The simulator is a great place for practising calmness.

Even professional drivers suffer from a mild form of pre-race jitters. In time, you will have learnt to tame these jitters. But that is illusory; the nerves are always present under the surface, ready to pounce with a slightest of provocation. Trying to stay calm can be very stressful, you see.

On a different note, there is a useful mental technique professional drivers often use is called visualisation. The driver sits in a chair, closes his eyes, and drives the lap in his mind. He sees in his mind's eyes every corner, the reference markers, the cornering line, the track surface irregularities, etc. He drives through each corner in his mind. He may even move his arms and legs, during this exercise. If he is good at visualisation, his mental lap would be almost the same as his actual lap. When you have learnt a track so thoroughly, you, too, can drive it in your mind. It is a good mental exercise. Try it.

Here is a word of caution. Driving is like any other human activity—experience matters. The longer you drive in a car on a track, the more familiar you become with both the car and the track. So, as the laps accumulate, the braking points, the amounts of steering wheel rotations, the levels of pedal forces, and the like become imprinted on your mind, they become habits. If you fail to recognise that tendency, your lap times will plateau out, because you will no longer try different ways of doing things. Stabilised lap times can be either good or bad. Consistent lap times are good, because they indicate that you have mastered the track and the car, provided your lap times are fast, when compared to most of you competitors. And of course there is a theoretical limit to how fast a given driver-car-track-weather combination can get. On the other hand, consistent lap times are bad, if you are slower than the competition, and you are not trying new things to improve yourself.

Of course, there are good habits, too. For instance, a habit of constantly scanning the immediate surroundings in order to maintain a situational awareness is a good thing. A habit of being gentle on the car is a good thing. And in a real-life race car, a habit of performing pre-race safety checks like a religious ritual is a good thing. You must cultivate these good habits, while you seek out and eliminate bad habits.

Another very important warning relates to a concept of psychology called *negative transference*. If you habitually drive recklessly in a consequence-free environment like a racing simulator, you are likely to transfer those bad habits onto a real-life race track, where consequences are as real as life and death. So, from the very start, treat the simulator seriously. Do nothing that you normally would not on a real-life race track.

And one more thing: do you know who your chief adversary is? It is the person who is by your side every waking moment of your day, the person who eats the same meals you do, the person who shares your bed, the person who knows your every thought, the person who knows you the best—you. You thought I was suggesting that your spouse is your chief adversary, did not you? Let me explain.

Your number one adversary is the person you were yesterday, the person who does the same things today as he did yesterday, the person who wallows in the successes of the past, the person who fails to explore beyond his comfort zone. If you drive the same way you have always done, if you do not seek out new ways to improve your performance, if you think you have nothing new left to learn about racing, then I have a bad news for you: you of yesterday is the best that you will ever be. Trust me; you really do not want to be bounded from above by your old self.

And what is true of racing is true of life. Always push yourself in everything you do: music playing, running, cooking, reading, theorem proving, everything. The danger, of course, is that you could become your harshest critic, a critic whom you could never please. Life is too short for such negativities. When you push yourself, you will make a hash of things, sometimes. Just learn to forgive yourself, learn from those mistakes, and push on.

Lastly, when things seem to be going badly in a race, remember the old racing maxim: never give up. Even if your car suffered a damage, if it is still safe and drivable, keep going till the end of the race, because those ahead of you may yet fail to complete the race. If the strong drops out, the meek shall inherit the lead.

Physical: The force feedback steering wheel and the pedals are quite capable of giving you repetitive strain injuries, both to your wrists and to your ankles. If you intend to race in long sessions, be it on a simulator or in real life, build up your endurance gradually, and strengthen your neck, shoulder, and arm muscles through regular exercise with free weights. At least on the simulator, we do not have to contend with the real-life longitudinal, lateral, and vertical g-forces, which have been known to turn the neck muscles into a sort of delicate fibres esteemed by toupée makers. Even if you never intend to drive on a real-life racetrack in the future, exercise will do you good; it will strengthen your body, and will soothe your mind.

Then, there is a condition called *simulator sickness*, which for a long time had been recognised by the driving simulator researchers—psychologists, doctors, and engineers alike. The symptoms include eye strain, headache, nausea, vertigo, and in worse cases, vomiting. And the ill effects can last from just a few minutes to several hours after the user stops using the simulator. Simulator sickness is particularly common among first time simulator users.

No one is really sure what the causes are, so theories abound. The most popular one is called the *cue conflict theory*[4], which asserts that the symptoms arise, because there is a mismatch between what the user's sensory systems expect based on his real-world driving experiences and what he sees and feels in the simulator. Hence, if the simulator is a bit off in the way it delivers the visual cues and motion cues, then the user may likely suffer from simulator sickness.

The symptoms are very similar to those of motion sickness, but the two conditions are not the same, because even fixed-base simulators, like the living room varieties, can bring on these symptoms. Because the peripheral vision is highly tuned to detecting motion, the fast flowing scenery at the left and the right edges of the display tricks the brain into believing that it is in motion at high speed, even though the user is sitting in an immobile racing seat. This conflict between the visual cues and the vestibular cues may bring on the symptoms. Another likely cause is the display flicker and fluctuating frame rate. Whatever the causes maybe, the ill effects are real. So, if you start to feel a bit icky, stop the session immediately, and walk away.

eye technique

The BMW E30 M3, a thirty-year-old road car, has a top speed around 230 km h^{-1}. At this speed, you are travelling at more than 60 m s^{-1}. To put it into perspective, you cover the length of a football pitch in the time it takes to scratch a nose itch, assuming you can quickly reach your nose with your bulky, gloved fingers through the narrow opening of your helmet's visor. When you are covering this much ground in this short a time, if you fixate on what is immediately in front of the car, you will fall behind the car. Humans simply do not possess the self-preserving instincts and the lightning-fast reflexes of the fruit fly; we need time to see, analyse, understand, decide, and react. So, do not focus on the patch of the track immediately in front of your nose; instead, gaze out to the next corner and beyond, while maintaining an awareness of the near field with your peripheral vision. The human peripheral vision is optimised to detect contrast and motion. Take advantage of it.

Identify braking references with the corner of your eyes, without shifting your gaze. Usually, a distance marker board, cones, or bollards are adequate references for corner-entry braking. But these objects are easily knocked over by an errant car, because they are too close to the edge of the track. So, if available, rely on more permanent references like trees, marshall's hutches, overhead signs, and the like.

Likewise, check whether anyone is trailing you, without refocusing your eyes to the mirror. Detecting a splash or colour or a shadow of movement in the mirror is sufficient to warn you that someone is attempting to overtake you.

This eye technique is especially important, when drafting to overtake. When you are drafting, you must look beyond the car immediately in front, and be aware of what is coming up ahead. At the same time, you must keep an eye on the mirrors, because an opponent directly behind may well be planning to pull off the same move on you. And you may even have to look through the front and the rear windshields of your intended victim's car, in order to time your overtaking move. You will find it unnatural at first to refrain from fixating on that car's boot, which is tantalisingly swaying mere centimetres in front of your bonnet. Practice this eye technique mindfully, and you will perfect it, eventually.

By the way, this is the same eye technique used in juggling. The juggler never looks at the balls. Instead, he fixes his gaze upon a distant object so as to widen his field of vision, then uses his peripheral vision to track the movements of all those balls. And just like the juggler catches the balls using only his proprioception, you must reach for the gear shift lever, the handbrake lever, the brake bias lever, and the like, without looking down into the cockpit.

Employing a proper eye technique is crucial, when launching off the starting line. When the green flag drops, everyone is on edge and everyone is jockeying for position into the first corner. There will be plenty of cars darting left or right, all around you. You will be doing the same thing. So, you need to be aware of not only the schemes of the opponents in front, but also the designs of those behind, while you craft your own tactics. Moreover, you need to watch out for the braking reference and the racing line through the first corner, where most first-lap crashes occur. Do not fixate on any one car. Instead, focus your gaze on the corner entry ahead, and use your peripheral vision to maintain situational awareness. Just be aware that sometimes, drivers stall on the grid or are slow to launch, so you must be prepared to go around them at any moment. You cannot afford the time to process a surprise; you must react instantaneously.

A good eye technique is equally important in cornering. As you rumble down the straight toward the corner, fix your gaze on the upcoming *corner entry*. As you approach the corner and the apex comes into view, shift your focus from the corner entry to the *apex*, and use your peripheral vision to sight the trackside object that is your braking reference. At some corners, the apex is hidden behind mounds, shrubs, or guard rails. In that case, look for the exit line. You can approximate the location of the hidden apex by estimating where the entry line and the exit line intersect. Upon reaching the braking reference, shift your gaze from the apex to the *exit reference*, while you decelerate and downshift into the cornering gear. Do not look at the apex as you clip it; instead, use your peripheral vision for that. As you clip the apex, shift your gaze again from the exit reference to the *farthest point* down the upcoming straight, and get back on the throttle. Keep the exit point in your peripheral vision, as you accelerate and drift out toward it. Here is a summary of the cornering eye technique:

- On straight: focus on corner entry
- At approach: focus on apex
- At braking reference: focus on exit reference
- At apex: focus on farthest point

hands and feet

In this section, we will talk about various driving techniques involving the hands and the feet: steering wheel holding, gear shifter manipulation, throttle pedal application, clutch pedal operation, brake pedal modulation, left-foot braking, right-foot lifting, and heel-and-toe double-declutch downshifting.

Hands: The classic racing *steering wheel* has three spokes arranged in the shape of a T. Hold the steering wheel at 3 o'clock and 9 o'clock positions where the bar (the horizontal bit) of the T joins the wheel, and rest your thumbs on the bars. As you turn into a corner, keep the hands in their original, anchor positions on the wheel and let your forearms cross, the outside one over the inside one. Initially, it is the outside hand that pushes the steering wheel toward the inside of the corner. But once the hands have passed the vertical, the fingers of the inside (now bottom side) hand open up to release the wheel, but the thumb continues to push the steering wheel at the T joint. By now, the outside (now top side) hand is no longer pushing the wheel, but is merely along for a ride to retain its anchor position. In the photograph below, the car is making a right turn, so the left hand is the outside hand, and is crossed over the right hand. At this extreme angle, it is the right hand that is pushing the steering wheel with its thumb. But the left hand is holding onto the wheel, in order to keep its anchor position.

The steering lock on a proper race car can be adjusted so that even the tightest corner on the track can be taken with the arms crossed no further than is comfortable, which is about 225 degrees to each side, or a total of 450 degrees. A road car steering wheel is not that sensitive; it may require more than two full turns to traverse lock-to-lock. So, to negotiate a tight corner in a road car, the hands will have to shift their positions, in order to crank the steering wheel far enough. There are two alternative hand-repositioning techniques for coping with a sedate steering: pulling and pushing.

The *pulling technique*, used by many real-life professional racers, is the technique S2U uses to animate the arms that appear in the cockpit view. In this technique, after crossing the forearms, the bottom side hand moves 180 degrees all the way to the top, and pulls on the steering wheel, while the top side hand repositions itself to the side of the steering wheel. This technique requires too much arm movement, and both hands must relocate themselves to new positions on the steering wheel. In the heat of battle, you could lose track of how far you have turned the steering wheel, because both your hands have lost their anchor positions. Moreover, the arms cross in an unnatural way, with both palms pointing down.

I favour the *pushing technique*, which works as follows. When entering a tight corner, do not start turning the steering wheel immediately, as you would at a typical corner. Instead, move the outside hand 90 degrees to relocate it to the bottom of the steering wheel by resting its thumb on the stem (the vertical bit) of the T, then push the wheel with that hand toward the inside of the corner, until the forearms become crossed. Meanwhile, the inside (now bottom side) hand releases its grip, and lets the steering wheel slide past it by 90 degrees. Thus, the inside hand has lost its anchor position, but the outside, pushing hand retains its grip and its anchor position. The outside hand is also the one that returns the steering wheel to its straight position, because it is the anchor hand. As the steering wheel unwinds, the bar of the T comes back under the thumb of the waiting inside hand. The forearms proceed to uncross, and everything returns to normal.

Despite the complicated description, the arm movement required in this pushing technique is minimal, yet it gives extra 90 degrees of steering wheel rotation to each side. So, we get 315 degrees of steering wheel rotation to each side, or a total of 630 degrees. Moreover, the arms are crossed in the familiar way, and only to a comfortable extent.

Racing steering wheel is small, and the steering mechanism is sensitive to minute movements of the hands. So, develop a light touch on the steering wheel. When traveling along a straight, keep the hands steady. Do not reflexively rock the wheel side to side, like a two-year-old driving a make-believe tractor. And do not grasp the steering with a death grip. Also, take care not to touch the flappy-paddle shifters accidentally with your hands, when rotating the steering wheel.

You must be equally precise and light, when manipulating the *gear shifter*, too. Precision is important, because you will crunch your gears on a real-life race car, if you are imprecise. But in S2U, you can never do anything wrong with shifting. And in Gran Turismo 6, you can never do anything right. Still, a proper use of the gear shifter is a good habit to develop.

A light touch on the shifter is important. If you are heavy handed, you will surely ruin your controller's shift linkages. Do not slam the shifter into the gate; just slide it into position. Indeed, avoid grabbing the shifter knob with the palm of your hand. Grasp the knob with the thumb and the first three fingers, with the little finger curled inward so that its top side rests on the shifter's stem just beneath the knob, as shown below. In other words, the knob is held lightly between the thumb and the little finger on the one side, and the three fingers on the opposite side. Because the shifter has a short throw, you can manipulate the shifter with the movement of the fingers and the wrist, without needing to move the entire arm.

And one more thing: keep your gear-shifting hand on the steering wheel as long as possible, and at the last moment move it to the knob. Do not develop a habit of driving with one hand on the wheel and the other on the stick.

Feet: When accelerating in a low gear, modulate the pressure on the *throttle pedal*. A race-tuned engine generates enough torque to over power the traction of the rear tyres, and to spin loose the drivewheels, even in third or fourth gear. So, be attentive to the sound of the rear tyres screeching. If the track surface is slippery or bumpy and the rear tyres are not biting well, you may not be able to reach full throttle, while accelerating in lower gears. If you try to apply full throttle in such a situation, all you would get is wheelspin. Nevertheless, even with a partial throttle, the engine will eventually spool up to the rev limit in the present low gear, at which point you must shift up to the next gear. There is no requirement that the throttle pedal must be on the floor, before shifting up.

And when releasing the *clutch pedal* to engage the selected gear, be smooth. If you pop the clutch, you will spin the rear wheels, or at the very least unsettle the rear end. In the worst case, you could damage the gearbox and the rest of the drivetrain. When the clutch starts to bite, usually when the pedal is almost halfway up, you may be able to quicken the pace of pedal release. By then, a sufficient amount of kinetic friction has developed between the clutch plate and the pressure plate, so a quicker release of the clutch pedal will not jolt the drivetrain. A typical road car has a forgiving clutch with a long travel. But the clutch on a race car is more temperamental, and demands a more sensitive left foot. Modern F1 cars use hand-operated clutch pedals, which are located behind the steering wheel, just beneath the gear shifter pedals. The F1 clutch pedals are used only to get moving from dead stop, not when shifting gears.

The most difficult thing to master for many racers, though, is the proper use of the *brake pedal*. Novice drivers are much too aggressive with the application of the brake pedal, and consequently they habitually lock up the wheels. They tend to mash the brake pedal in hope of shedding speed as quickly as possible. And even if they manage to avoid wheel lock-up, they release the brake pedal much too abruptly, the moment the car has slowed down enough. Unceremoniously popping off the brake pedal in this manner removes the retardation force suddenly, which disturbs the traction of the tyres, right at the moment when they are asked to do their utmost to keep the car on the cornering line.

The proper technique is to get on the brake pedal quickly but smoothly, then gradually reduce the pedal pressure, as the car sheds its speed. The slower the car gets, the less brake pressure you must apply, in order to avoid wheel lock-up. Come off the brake pedal in a similar manner to the way you come off the clutch pedal: gradual release until about half way up, then quicken the pace.

Another useful trick is *left-foot braking*—the application of the brake pedal with the left foot, instead of the right. Left-foot braking is just the thing to do in modern race cars equipped with clutch-pedal-less, sequential, manual gearboxes. You no longer need the left foot to operate the clutch pedal, so you might as well use it to operate the brake pedal, thus saving a few fractions of a second that would otherwise have needed to switch the right foot from the throttle pedal to the brake pedal.

But there are more ancient uses of left-foot braking. In the olden days when race cars had three pedals, a touch of left-foot braking was used to transfer load to the front, so as to give a bit of extra traction to the front tyres, thus reducing corner entry understeer. In a classic, three-pedal car, the left foot rests on a dead pedal on the left side of the footwell, when it is not operating the clutch pedal. To operate the brake with the left foot, you lift your left foot off the dead pedal, roll it on its heel, and dab the brake pedal with the ball of that foot. Then the left foot rolls back to its perch. Another use of left-foot braking is on older, turbocharged cars, which suffered from a turbo lag. The turbo on these cars take time to spool up. So, left-foot braking without lifting the right foot off the throttle pedal keeps the turbo spinning, even while the brake is applied, thereby allowing the car to resume accelerating without a turbo lag.

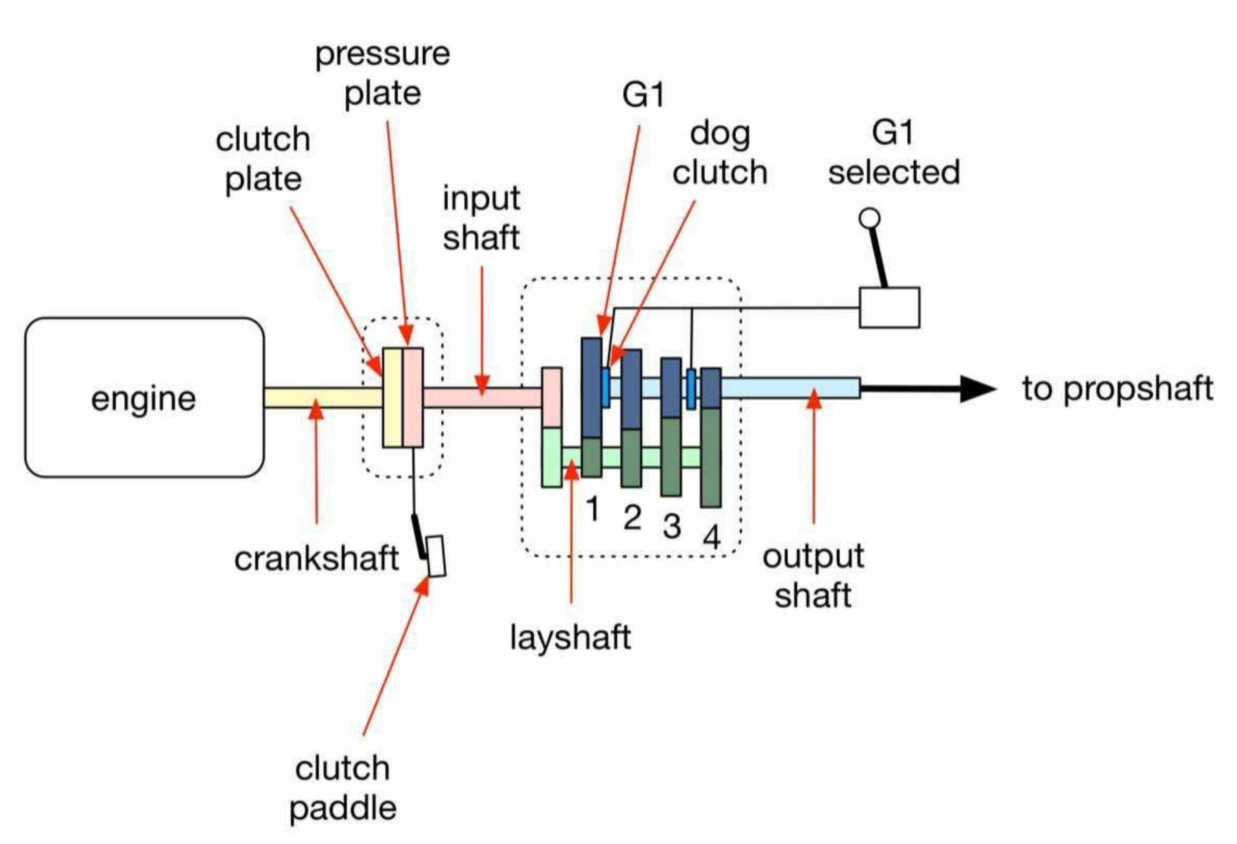
There is also *right-foot lifting*. It is used to cope with a less severe case of corner entry understeer. Lifting the throttle pedal slightly reduces the engine speed, which slows down the drivetrain and the drivewheels. The resulting momentary deceleration transfers a bit of load to the front, and the front tyres gain just enough extra grip to mitigate understeer.

So, to cure a slight understeer at corner entry, lift the right foot, partway. To cure a more severe case of corner entry understeer, use a dab of left-foot braking.

Hands and feet: Now, let us discuss corner entry *heel-and-toe double-declutch downshifting*, or simply heel-and-toe. This technique is utterly unnecessary in S2U, since this simulator does not implement a realistic clutch. But it is loads of fun when done right, so I shall describe it for you.

The purpose of the heel-and-toe technique is to enable smooth downshifts by matching the speeds of the gearbox's input and output shafts. Despite the fact that it is an essential technique for driving a three-pedal race car, there is much confusion about this technique among the novice, perhaps because not too many people drive cars with stick-shift, manual gearboxes anymore, or maybe because the clutch, the gearbox, and the rest of the drivetrain are hidden away from view. Be that as it may, I shall try my best to demystify this important technique, here.

Below, I provide a two-pass description of the heel-and-toe downshifting technique. In the first pass, I describe how to perform the steps. In the second pass, I explain why the steps are necessary. But before you proceed, you may wish to review the gearbox section of the race car components chapter.



Here is *how* you heel-and-toe downshift from G4 into G3, while approaching a corner. Below, the letters "CBT" refer to the states of the clutch, brake, and throttle pedals. Upper case means the pedal is up, and lower case means the pedal is down.

- **CbT**: Lift your right foot off the throttle pedal, and press it down on the brake pedal. Modulate the brake pedal pressure, throughout this entire sequence.
- **cbT**: Depress the clutch pedal (declutch) with the left foot, take the gearbox out of G4, shift into neutral.
- **CbT**: Release the clutch pedal, but keep your left foot hovering over the clutch pedal.
- **Cbt**: While continuing to modulate the brake pedal with the ball of your right foot, simultaneously pump the throttle pedal with the side of your right foot.
- **cbT**: Depress the clutch pedal (declutch) again, and snick the shifter into G3.

- **CbT**: Release the clutch pedal, but hang your left foot over the clutch pedal.
- **CBt**: Proceed down through the gears in like manner, until you reach the cornering gear. Finally, upon reaching the cornering gear, lift your right foot off the brake smoothly, and roll it back down on the throttle, as you simultaneously lift your left foot off the clutch.

In the sequence above, the clutch pedal is depressed twice. Hence the name “double-declutching.” And although the ball of the right foot and its side are the ones actually used, and not the heel and the toes, this technique is called “heel-and-toe,” nonetheless. Now, let us examine *why* you need to perform these steps:

- When you declutched the first time, the clutch decouples the gearbox’s input shaft from the engine’s crankshaft. The engine no longer supplies power to the drivetrain, at this point. The gearbox’s output shaft is now being rotated by the drivewheels via the differential and the propshaft. The output shaft speed is, therefore, determined by the speed of the drivewheels, which are in turn determined by the speed of the car. Since the dog clutch is still meshed to G4, the output shaft, the output shaft gears, the layshaft gears, the layshaft, and the input shaft are still rotating together.
- Now, you are able to slip out of G4 and into neutral with ease, because the throttle is closed, so the drivetrain is not under load. Once you have put the gearbox into neutral, the dog clutch is no longer meshed to G4 on the output shaft. Although the output shaft continues to rotate at the speed of the drivewheels, the output shaft gears are now rotating independently of the output shaft. And because the clutch pedal is still depressed at this point, the input shaft, the layshaft, the layshaft gears, and the output shaft gears are not connected to any external drive. These bits are, therefore, rotating under their own rotational inertia. Racing gearbox components possess very low mass, so they have low rotational inertia. Consequently, they slow down very quickly, in the absence of extern drive.
- When you release the clutch pedal, the clutch recouples the crankshaft to the input shaft. Now, the input shaft, the layshaft, the layshaft gears, and the output shaft gears are rotating at the same speed as the engine.

The output shaft, however, continues to rotate at the speed of the drivewheels.

- Because the throttle is still closed, the engine speed has now dropped well below that of the drivewheels. Racing engine components, too, possess low rotational inertia, so they shed their revs in a hurry. If you try to shift into G3 at this point, the dog clutch will grind against G3, because the dog clutch is rotating at the speed of the output shaft, but G3 is rotating at the speed equal to the engine speed reduced by the gear ratio of G3. In other words, G3 is rotating much more slowly than the dog clutch. So, to avoid crunching G3, you speed it up with a quick pump on the throttle pedal. Releasing the clutch before pumping the throttle reengages crankshaft to the input shaft, thereby enabling you to use the engine to speed up G3.
- With G3 and the dog clutch speeds momentarily matched, you declutch the second time, and glide the shifter down into G3. To avoid speed desynchronisation, you must declutch and shift down very quickly.

When heel-and-toe double-declutch downshifting, all four limbs are moving independently and fluidly. These steps must be executed quickly, and each must be timed precisely. For that, you need to develop four-way independence in your limbs. It takes but a moment to execute this sequence, but it may take a considerable amount of practice time to master it. Because heel-and-toe is used multiple times during each lap, being able to perform it accurately, precisely, and efficiently will improve lap times. Moreover, there are loads of other things you have to do at corner entry, in addition to heel-and-toe: tracking the opponents, sighting the braking reference, placing the car on the cornering line, sighting the apex, and more. So, practice heel-and-toe. Master it.

And I cannot stress enough that you develop a light touch on the controls. Do not grasp the shift lever with a death grip, or slam it into a gate with excessive force. Brute force will not make you go faster; it will only break your equipment. Similarly, do not mash the brake pedal; instead, quickly, smoothly, and firmly apply pressure on the brake pedal with the ball of the foot. Modern brakes shed speed efficiently, so be alert to modulate the brake pressure to avoid locking up the wheels. Learn to sense the steering wheel going light at the onset of front wheels lock-up. Modulate the brake pressure; do not torture the front tyres. Be sympathetic to your car, and it will take you far.

There are a couple of lazy shortcuts to this rather complicated technique of heel-and-toe double-declutch downshifting. The first one is the *single-declutch downshift*. This shortcut is commonly employed with synchromesh gearboxes found on the more recent classic cars. In this technique, you declutch, and immediately shift into the lower gear, while simultaneously pumping the throttle. The throttle blip matches the engine and the drivewheel speeds, so you avoid unsettling the car, just as you did with the double-declutch technique.

However, because the input shaft, the layshaft, the layshaft gears, and the output shaft gears are decoupled from the engine and the output shaft, these components are slowing down very quickly. Hence, there is a large speed mismatch between the output shaft gear and the corresponding dog clutch, when you try to shift into that lower gear. The task of speeding up all of those slow-rotating components falls to the tiny synchroniser ring, which sits between the shift collar and the output shaft gear. Over reliance on the synchronisers will wear them out, and will eventually damage them. Hence, even on synchromesh-equipped cars, I favour the old, double-declutch technique. If you want more details on how the synchroniser aids gear selection, see WeberAuto’s YouTube video explaining the operation of a synchromesh gearbox at timestamp 4:30.

By the way, the gearbox shown in the diagram above is called a crash gearbox, because the dog clutch crashes into the corresponding output shaft gear, without the aid of the speed synchroniser.

Another shortcut is to stay on the brake until you have slowed to the cornering speed, then heel-and-toe *downshift directly into the cornering gear*. But there is a substantial risk of over revving the engine, when using this shortcut. If you shift into a low gear while the car is still going too fast, the speed of the drivewheels, multiplied by the gear ratio, can over rev the engine beyond its rpm limit. The engine is now a ramekin of crème brûlée.

In the days of yore when drum brakes were in vogue, stepping down through the gears in sequence was just the thing to do, because the feeble drum brakes needed the engine braking assistance to slow down a fast race car. Engine braking, also known as coasting, occurs when you lift off the throttle while the gearbox is still in gear. The engine's internal friction slows down the rotation of the rear drivewheels, so coasting aids the brakes in decelerating the car. But highly efficient modern disc brakes, made of exotic materials, obviate the need to employ engine braking. However, I still favour stepping down through the gears, because it reduces the likelihood of accidental engine over revving.

There is a catch with heel-and-toe, though. You cannot simply blip up to a random engine rpm. You must rev the engine to match the speed of the drivetrain. So, how do you know what rpm to rev up to, when you downshift? Well, you must blip the engine rpm up to what it needs to be in the intended lower gear, so that the drivetrain speed remains about the same, when you engage that lower gear. In a living room simulator like AC, we need not be so precise. But if you want the exact numbers, try this.

Start down a long straight, say at Monza historic, in the BMW E30 M3 road car in its factory set-up. Accelerate in G1 up to the redline at 7,000 rpm. The car's road speed will be 72 km h^{-1}. Now, shift up to G2, and maintain that speed. You will notice that the engine revs drop from redline to 4,500. If you climb up the gears, you will see that in G3, the engine revs at 3,400; in G4 at 2,500; and, in G5 at 1,900. We now have the rpm deltas between the gears:

- Downshift to G4 from G5: 2,500 - 1,900 = 600 rpm increase
- Downshift to G3 from G4: 3,400 - 2,500 = 900 rpm increase
- Downshift to G2 from G3: 4,500 - 3,400 = 1,100 rpm increase
- Downshift to G1 from G2: 7,000 - 4,5000 = 2,500 rpm increase

Hence, if you enter a corner and heel-and-toe down from G4 to G3, you must blip the engine to rev up by 900 rpm above its present G4 rpm. But since you need to account for the engine slowing down in that fraction-of-a-second that it takes you to go from neutral into G3, you should rev up slightly more than 900 rpm above the current rpm. Note also that these rpm deltas will change, if the gear ratios change. Suffice it to say, this is much too fussy. In practice, we just blip the throttle by feel, based on experience. Pedantry looks good on paper, but touch is more important on track.

And there are real-world racers who use the clutch pedal very infrequently, perhaps only to launch off the line. Instead of using the clutch for every shift, an experienced driver shifts by matching the revs. To upshift, he lifts up the throttle partway to unload the drivetrain slightly, slips out of the current gear, immediately snicks up into the next higher gear, and returns to full throttle thereafter. The engine will rev at a lower rpm in the higher gear, and partially lifting the throttle drops the engine rpm. So, all that he needs to do is to shift up, when the engine revs have dropped by a sufficient amount. To downshift, the driver lifts up the throttle a bit, disengages the gear into neutral, blips the throttle, and snicks down to the next gear, all the while modulating the brake pedal pressure. Try it in the M3 road car. You may grind the gears, initially. But with a little practice, you can shift without the clutch. I use the clutch, though, because I enjoy the full experience of a well executed heel-and-toe double-declutch downshifting.

To the chagrin of many serious drivers, most simulators do not model gearbox damage. S2U is no different. But Assetto Corsa implements gearbox damage, the way it models clutch bite, gear shifts, and miss shifts is simply flawless.

Yes, this is all very stodgy, I know. And you can abuse the gearbox in S2U with abandon, so you need to know how to use the heel-and-toe technique. But this knowledge will not only make you a better driver, it will also give you a greater enjoyment, when you have learnt to do things right. I recommend that you watch the YouTube video of the manual gearbox operation by Automotive Basics. I also suggest that you watch the Monaco clip from the 1966 film *Grand Prix* at timestamp 3:05, and study how a professional race car driver form the 1960s performs the heel-and-toe double-declutch downshifting. And if you are interested in learning more about clutch, gearbox, gear ratios, and the like, read Carroll Smith's book *Drive to Win*.

Here is a bit of detour. Real-life racers wear *racing shoes* that have thin soles and rounded heels, like the Piloti Spyder S1 shown below[5]. Thin soles allow us to feel the pedals more acutely. Rounded heels make it easier to roll our feet on the heels, when we heel-and-toe downshift. The Spyder even has a dark-grey, hardened pad on the right side of the right shoe, which is used to blip the throttle. The left shoe does not have a similar pad.

launching

Many a race has been won at the drop of the green flag, by the driver who can seize the lead and control the race from the front. Suffice it to say being able to execute a good launch is essential. And although S2U's modelling of the launch is not the most realistic I have seen on a simulator, it is acceptable, nonetheless.

Unlike the more serious, PC-based simulators, S2U does not implement the launch control. But that does not hinder us in any way, since we are driving a classic sports car that does not have a launch control, at least in its street-going variety. To launch in S2U, depress the clutch and rev up the engine to about 75% of the redline, as the starting red lights come to life. When the final light turns green, release the clutch quickly and smoothly, while modulating the throttle so as to forestall spinning the rear wheels. Avoid stomping on the throttle pedal or popping off the clutch pedal. If the car begins to oversteer due to loss of traction at the rear, counter steer smoothly and ease up on the throttle a bit. As the rear wheels regain traction, continue accelerating.

The optimum launch RPM of the engine varies with power output, gear ratio, suspension set-up, weight of the car, tyre compound, track surface, and environmental conditions. You can find that optimum RPM in S2U's HUD. Enter a race. At the starting line, press the **Cycle HUD Mode** button once from the helmet view. This turns on the HUD. Shift into first gear, and hold down the clutch pedal. The current gear is displayed as a white number in the lower-right corner of the HUD. Now, gradually press the throttle pedal. When the optimum engine RPM is reached, the white gear indicator turns green. Note the engine RPM and hold the throttle there, as you await the green flag. Return to helmet view. This aid is not available in the testing, so it behoves you to memorise what your car's launch RPM is. And if you upgrade the drivetrain, the optimum launch RPM may change.

On some cars, if you use the RPM prompted by the green gear indicator, you can end up bogging down the engine, almost to the point of stall. If that happens, increase the launch RPM by 500, and try again. Repeat until you find the RPM that works for that car. Remember though that higher launch RPM is more likely to cause wheel spin. Launching a race car is an art form that requires patience, dexterity, and practise. Even some of the top F1 drivers botch the launch, from time to time. So, do not be disheartened, if you cock it up. Practise.

corner layouts

A typical, modern racetrack has one long, pits straight and a string of corners lashed together with short straights. Some have a short back straight, but many do not. Along the straight, there may be an occasional drafting and overtaking, but not much else goes on. So, real-life drivers use the long straight to relax a little—adjust the harness, communicate with the race engineer, take a swig from the water bottle, scratch an itchy nose, write a birthday card for mum, and so forth.

In contrast, corners are rather busy places. The head and the four limbs of the driver are in continuous motion during cornering. Many spectacular overtaking manoeuvres and equally impressive defensive manoeuvres occur at corner entries. The corners are also where the best drivers gain time on the merely good ones. Also, how much speed the driver can carry through a corner determines his maximum speed on the subsequent straight. Here is why. A higher cornering speed means the driver gets on the straight with a higher initial speed, and a higher initial speed means a higher termal speed at the end of the straight. Suffice it to say corners are important. Consequently, we devote a lot of our attention in this book to cornering techniques.

In the next section, I present cornering techniques. But before we can talk about cornering techniques, we must first discuss corner configurations. I use the term *corner configuration* to refer to the combination of corner layout and corner characteristics. Traditionally, *corner layouts* are categorised as follows: fast bend, increasing radius corner, constant radius corner, decreasing radius corner, double apex corner, S-curve, chicane, and hairpin. And each turn on a track also has a unique set of *corner characteristics*. Many corners are helpfully banked to the inside, but some are adversely cambered to the outside; some have crowned surfaces, the insides of which may be used as a shallow banking to increase cornering speed; some are downhill, while others are uphill; some are bumpy, but others are smooth; and, some have a combination of several different characteristics.

In addition to corner layout and characteristics, there are other parameters that colour the corners, such as *track surface construction*, which refers to the roughness of the construction materials of the track surface, and *track surface condition*, which refers to the presence of dust or moisture on the track surface. The construction does not change with time, but the condition does.

We can safely say that no two corners are alike. Even if two corners appear to have similar layouts, their characteristics are different, because the real estate upon which they sit are unique. Factoring in the track surface materials, weather, tyre compound choices, rolled-up rubber bits shed by tyres, dust, gravel, fallen leaves, cornering speed, skill, concentration, nerves, fitness, and opponent personalities, each corner offers a challenge that renews itself, lap after lap. So, even a relatively short racetrack is never boring, and no two laps are ever identical, especially in the context of online races. These perpetually renewed challenges differentiate real-time simulators from mere games.

Each corner layout has associated with it a *conventional cornering line*—the theoretically optimal path to take, when traversing the corner. But the corner configuration and track condition may demand a modification to the conventional line, so as to gain a bit of extra speed, or to avoid losing speed. For instance, at a corner with an adverse camber, the car may slide off the track, if you follow the conventional cornering line. In that case, if you do not alter your line, you maybe obliged to tiptoe through the corner. And if a corner has a bumpy patch on the conventional line, it may be preferable to go off the conventional line altogether to avoid the unpleasantness.

Some PC-based simulators, like AC, rFactor 2, and other respected titles, implement track surface condition changes due to time of day, weather, and dust. On those simulators, as in real life, the track surface improves as the laps grind on, because a layer of rubber is laid down on the racing line. This rubber, of course, was donated by the tyres. If you get off the racing line though, you will experience a significant loss of traction, because the off-line track surface is littered with marbles—little bits of rolled-up rubber shed by tyres over the course of the race. And the dust and debris that had earlier been on the racing line have been swept off the line by the rolling tyres, and are now accumulating off the line, alongside the marbles. So, try to stay on the racing line, even if there is plenty of space available off the line.

And in wet weather, you will be obliged to take a less aggressive racing line, a line that avoids the kerbs. Mounting a tall, painted kerb in the rain will likely spin the car, and the wet track will only quicken the car's departure from the track. Also, stay off the white-painted track edge marker line, when the track is wet. The paint is particularly slippery, when wet.

Most drivers will take the fastest line round the track. Over the course of a race, a dark line forms through every corner. This line is where the most rubber is laid down, because the majority of the drivers prefer that line through the corner. This is called the *consensus line*. The consensus line is usually the fastest line through that corner. But occasionally, it may not be the optimal line. So, it behoves you to try a couple of different lines through corners, seeking different corner characteristics to exploit.

Lastly, I will say a few words about an oft-repeated racing maxim, “slow in, fast out,” which admonishes those daredevils who charge headlong into a corner. What the saying means is that carrying an excessive speed into the corner will induce understeer, so to go fast through a corner, enter slowly, settle the car on the cornering line, then exit fast. But this simplistic guideline is not the best advice for every corner on every track. Indeed, you may disregard it altogether, once you have gained sufficient racing experience, and have developed your own driving style. At present, however, remember to enter a corner gingerly, settle the car and clip the apex, point the car at the exit, and fly out of the corner. But always try to find the maximum speed that you can carry through every corner, during the practice session. Break down the corner into the phases we discussed earlier, and optimise the speed through each phase. I will have more to say about this matter in the racing tactics section, later.

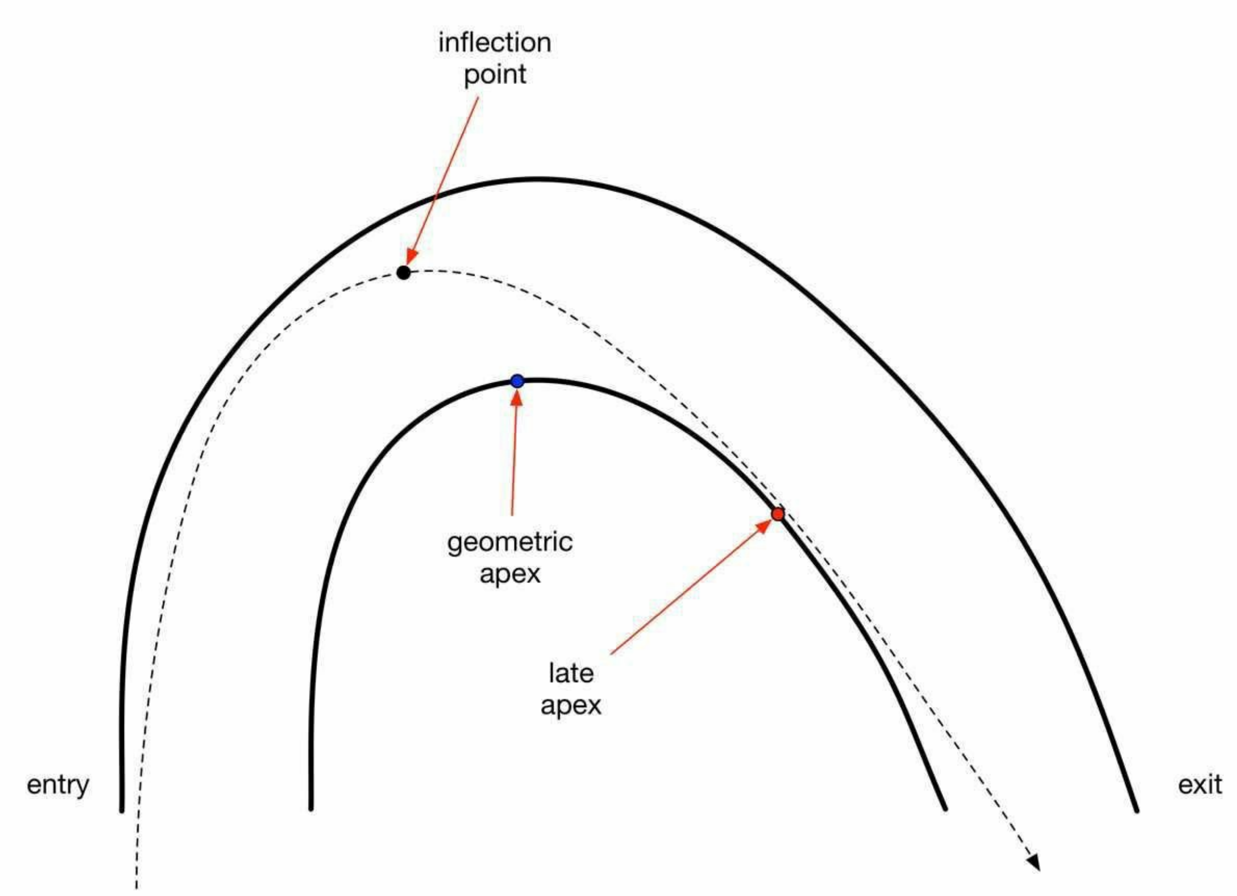
Now, let us turn our attention to the conventional cornering lines through different corner layouts. Remember, the lines I describe below are only suggested lines. Master them, but experiment with alternative lines through every corner on every track you drive. And one more thing: the absolute speed through the individual corners is less important than minimising the overall lap time. Hence, there maybe times when you must sacrifice a corner so as to position yourself better to take the next, if it means you improve your lap time.

fast bend

A fast bend, as the name suggests is a point where two straights connect at an obtuse angle. Because the curvature of this type of bend is very slight, some drivers may not reduce speed at all, and instead take the bend in full throttle. Indeed, a fast bend maybe so slight that it is barely noticeable. In such as case, it is considered a part of the straight, and is not designated as a corner. There is not much more to a fast bend, other than perhaps a few bumps and dips, here and there.

increasing radius

Increasing radius corner is tighter at the entry but opens up at the exit. The radius of the earlier part of the corner is smaller, and hence the curvature there is greater (curvier). The radius of the latter part of the corner is greater, and the curvature there is commensurately smaller (straighter). Because we wish to settle the car as early as we can and because we wish to straighten the exit line, we enter the corner at a slower speed. All the while, we keep the eyes on the apex, which occurs much later on the exit side. In the diagram below, the apex (red dot) is the point where the cornering line touches the inside edge of the track. Once we have passed the inflection point (black dot) where we changed directions, the car should be pointing at the exit. All we need do now is to accelerate smoothly out of the corner.

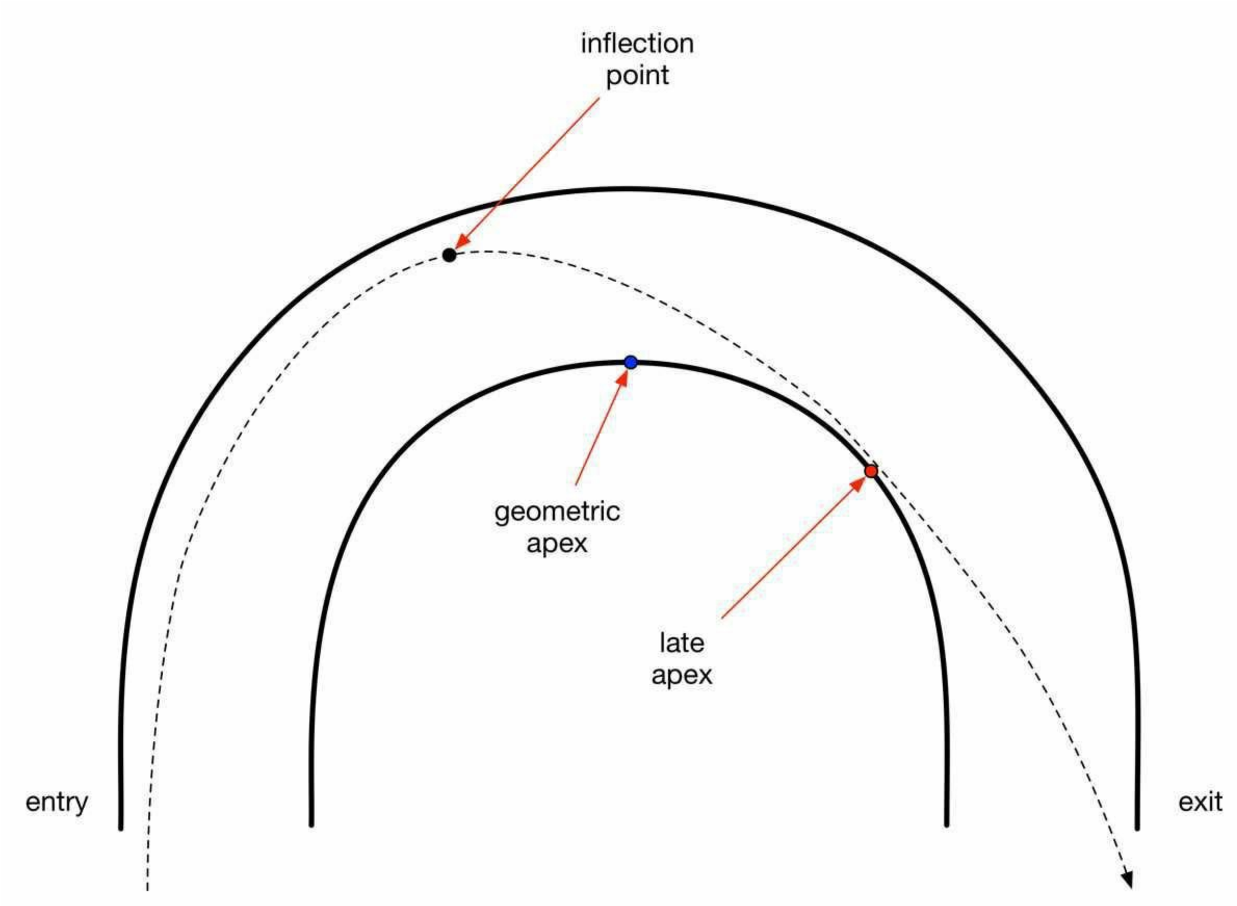


In the above diagram, the geometric apex (blue dot) is the point on the inside edge of the track where the edge inflects. It is the sharpest point on that edge. The cornering line's inflection point and apex almost never coincide with the geometric apex. You will note in this diagram that the exit curvature of the cornering line (dotted line) is much more gradual than that of the track. In other words, the cornering line is straighter than the track itself, on the exit side. Had we hugged the inside edge of the track—the shortest path through the corner—we would have followed a path with a greater exit curvature. This would have reduced our exit speed considerably. A slower exit speed means we arrive at the next corner with a lower top speed. Corner after corner, these ill effects compound, and they ruin your day.

Through most corners on most tracks, we try to maximise the exit speed at the cost of the entry speed. That is, the cornering line is tighter at the entry, but it gets progressively more gradual at the exit. If you are uncertain about the best line through an unfamiliar corner, try this line first. Because this tighter-then-wider cornering line is usable at many corners on many tracks, we shall give it a name: the *late-apex cornering line*.

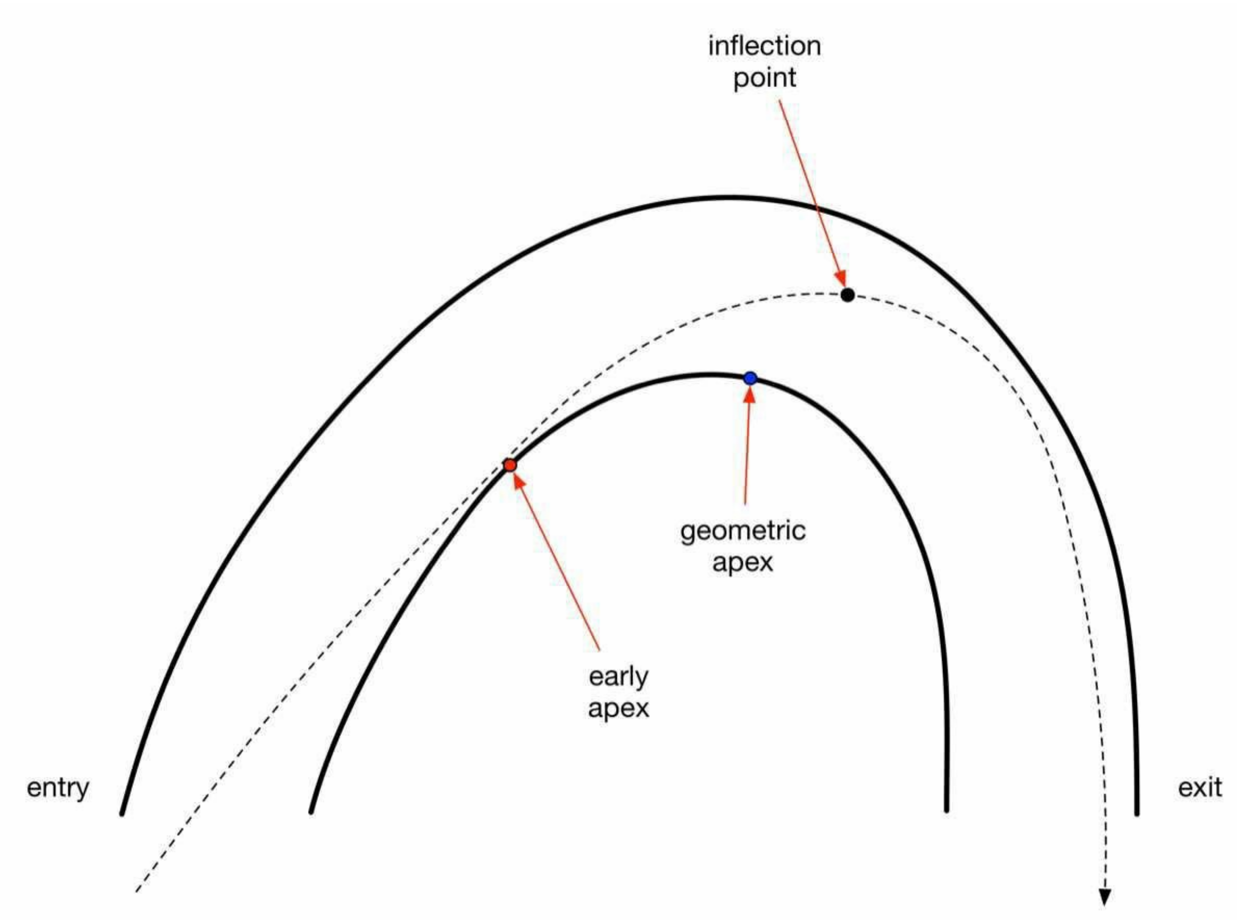
constant radius

A corner whose radius remains the same from the entry to the exit, as shown below, is called a constant radius corner. The conventional racing line through this corner is the same as that for the increasing radius corner—the late-apex cornering line. But because the constant radius corner has a bit more manoeuvring room at the entry, we may not need to sacrifice the entry speed as much as we did in the increasing radius corner.



decreasing radius

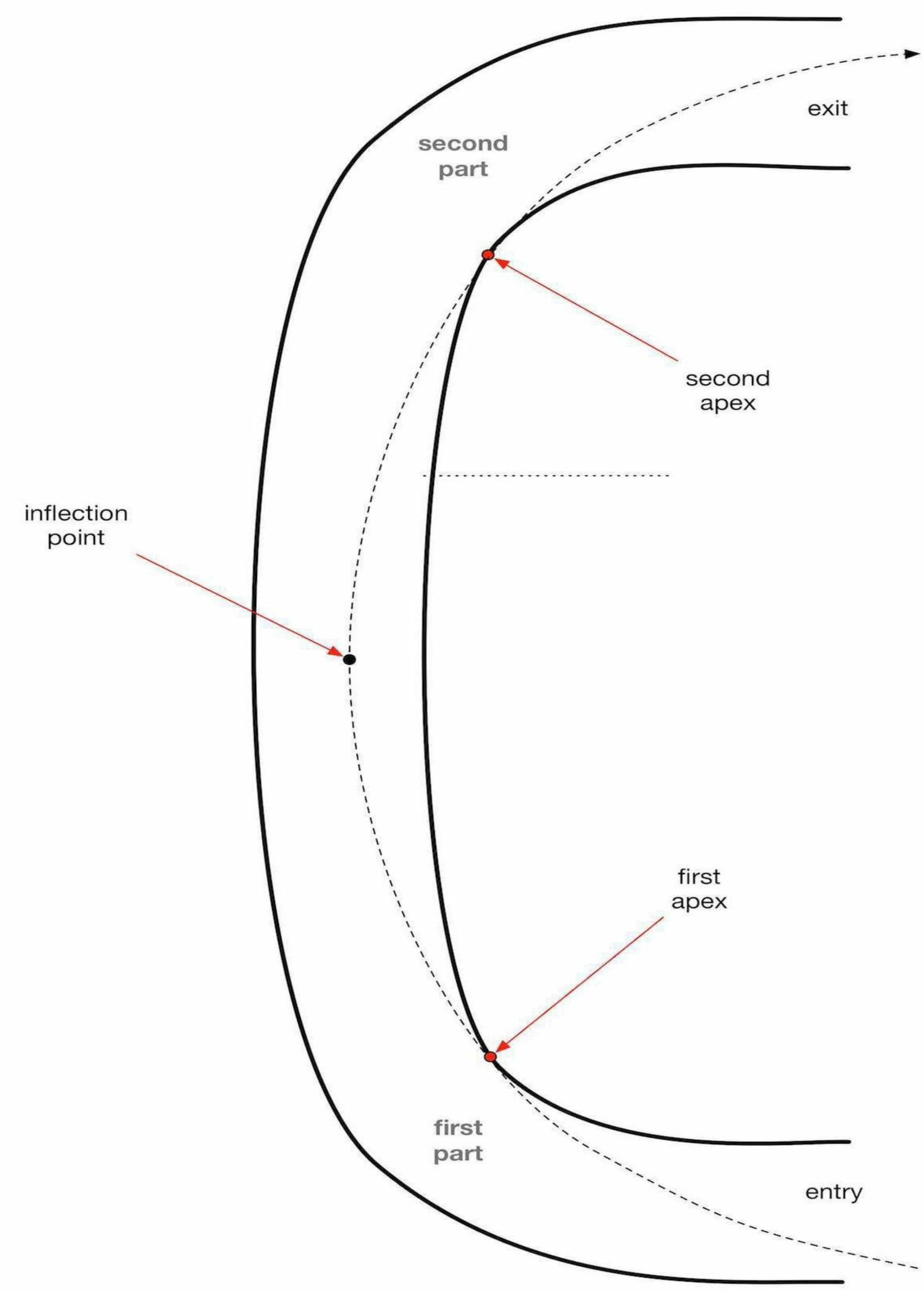
The decreasing radius corner is the mirror image of the increasing radius corner. It progressively tightens. Because there is very little room to manoeuvre at the exit, the cornering line's exit curvature is necessarily greater. So, we have no choice but to settle for a lower exit speed. But since there is more room at the entry, we take advantage of that, and maintain a higher speed deeper into the corner, thereby straightening the entry line as much as possible. And we clip an early apex, while we are still on the entry side of the corner. The mid-corner neutral throttle phase is usually very short in this type of corner.



Note that it can sometimes be difficult to discern whether a corner is an increasing radius, a constant radius, or a decreasing radius type. So, we should always study the satellite map of an unfamiliar track and note the layout of each corner, before we get on the track.

double apex

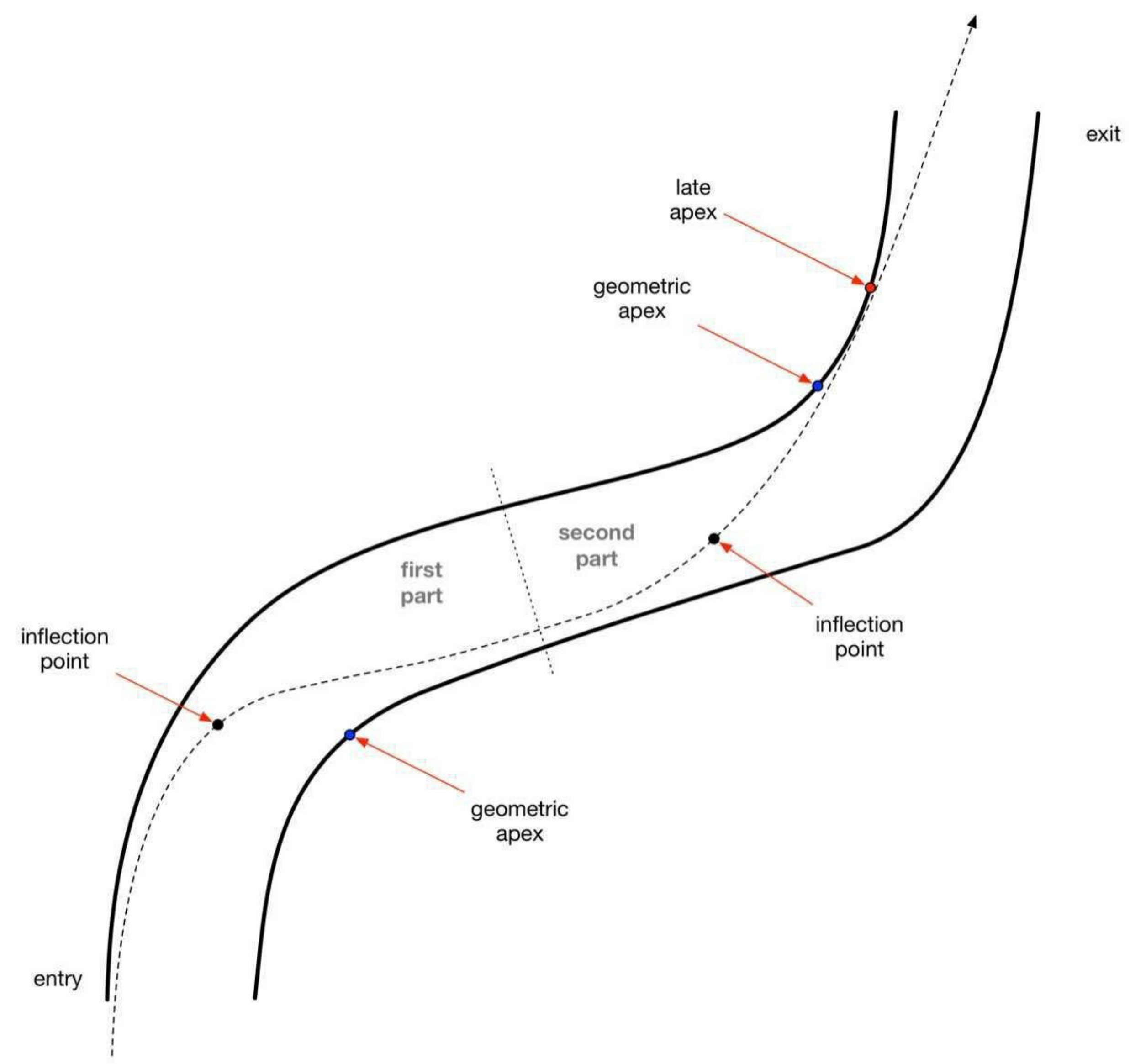
When two corners turning in the same direction are situated very close to each other, it is possible to take one racing line through both of them, clipping both the apexes, as shown below. By taking one smooth line through both corners, we maximise the overall speed through the entire complex. The neutral throttle, mid-corner phase is typically quite long in this type of corner.


exit
second part
second apex
inflection point
first apex
first part
entry

Some tracks have corners with more than two apexes, like Turn 8 at the Istanbul Park, the site of the Turkish Grand Prix. What a neck stretcher, that one.

s-curve

An S-curve is a left-right or a right-left flick, as shown in the diagram below. Sometimes an S-curve can be quite subtle. In that case, you can almost take a straight line through the whole lot. Often, multiple flicks occur in a sequence. Then, the whole sequence is called the esses. Silverstone circuit's Maggotts-Becketts-Chapel complex is one such sequence.



Because an S-curve is a combination of two opposite turns, there are two inflection points on the racing line. Typically, the racing line through an S-curve sacrifices the entry speed in favour of a higher exit speed. We make this sacrifice, because a straight usually follows this type of curve, and we want to get on the straight with a higher initial speed. The higher the initial speed with which you get on the straight, the higher the terminal speed at the end of the straight, and the better the lap time. So, you must do what it takes to extract the maximum exit speed from the S-curve, even if it means you have to sacrifice the first part by traversing it more slowly and by missing its apex, as shown in the diagram above. But in so doing, you position the car better for the exit, and attain a higher exit speed onto the following straight. You can also see in the diagram that the exit line is noticeably straighter than the entry line. Incidentally, this exit line is the familiar, late-apex cornering line.

chicane

A chicane is a very tight sequence of corners, typically laid out as one or two S-curves. It usually appears just before the front straight, where the pits are located. The main purpose of a chicane is to slow down the cars to a safer, slower speed, just before they pass by the busy pits. This was necessary half a century ago, when the exposed pits were located just a few metres away from the racing line. Today, the pit lanes are protected behind safety barriers and pit speed limits are strictly enforced, so chicanes no longer serve their original function. Yet, they continue to be prominent features on modern racetracks, because they are still relevant, today.

The reasons why the chicanes are popular with drivers and spectators are as follows. The last-corner chicane slows down all the cars so that those entering the pits can peel off safely into the pit lane, and the rest can continue their way onto the front straight. And it is a great place for overtaking. On the back straight, a driver would tuck in behind an opponent’s draft. In the braking zone of the chicane, he would jump out from behind, and occupy the inside line to take away the position, right in front of the cheering crowd in the grandstands. For the same reasons, the last-corner chicanes remain a favourite with modern racetrack designers, as well.

hairpin

A hairpin is the tightest turn on the racetrack. Monaco has the famous

Lowes hairpin, and Spa the equally famous La Source. The conventional, late-apex cornering line usually works for this type of corner, but it is not always the practical choice, due to the corner characteristics—tightness, bumps, banking, gradient, kerb, guard rail, etc. And if the hairpin is very tight, it is of no consequence whether its layout is increasing, constant, or decreasing radius variety. Then, it is preferable to take the shortest line through it.

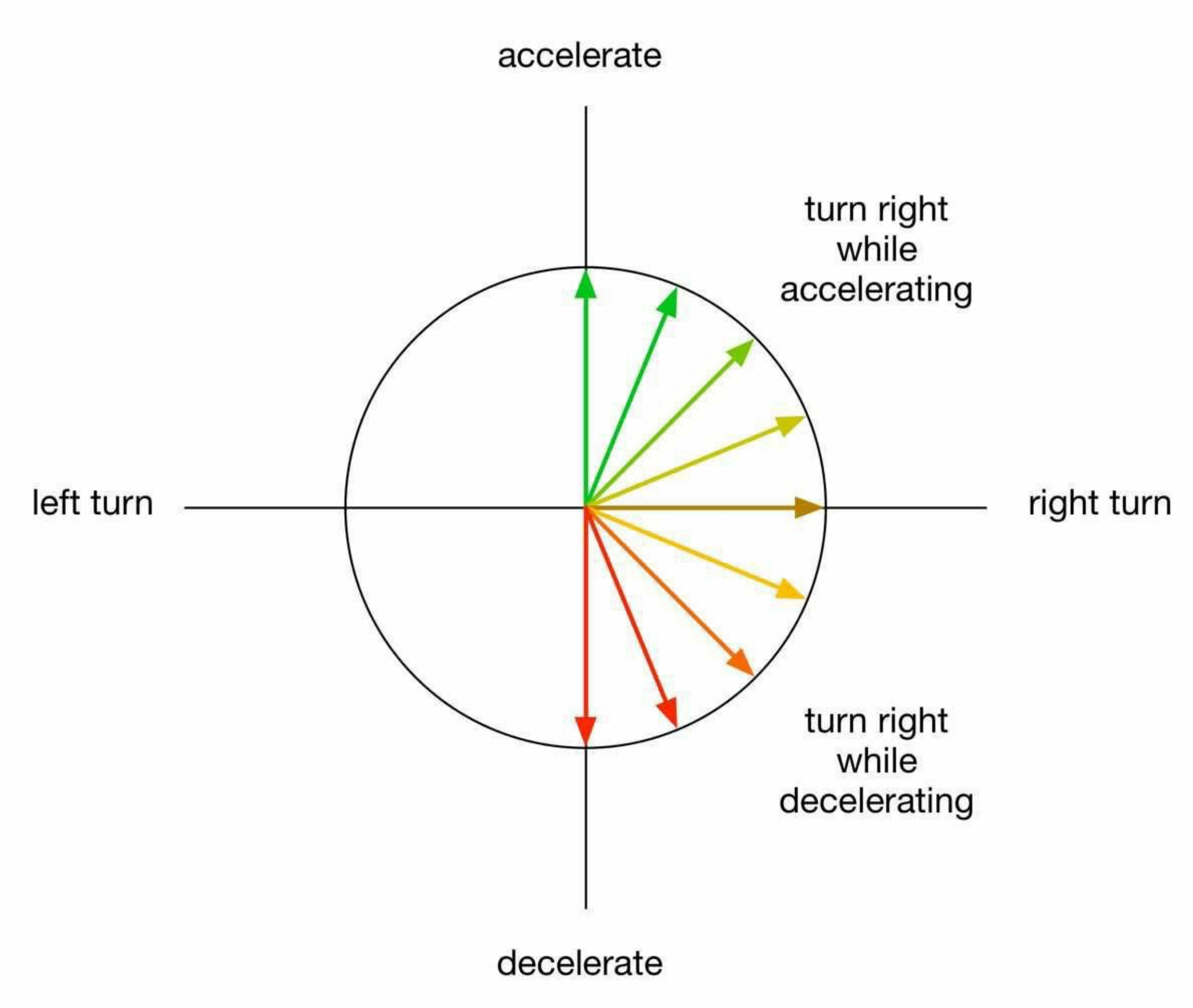
cornering techniques

I stated earlier when we discussed load transfer that racing is mostly about cornering, and cornering is all about managing load transfer, because load transfer affects tyre traction. In this section, I describe the cornering techniques that manage load transfer and tyre traction, with reference to the familiar driving phases: hard braking, trail braking, neutral throttle, initial acceleration, and hard acceleration.

Earlier admonitions against entering the corner with excessive speed and accelerating while the steering wheel is still cranked are worth repeating, because these are very common novice mistakes. The former will yield corner entry understeer, and the latter corner exit understeer.

going round in circles

Race driving instructors are fond of saying, “carry speed through the corner.” What is it exactly that one must do to effectuate that pithy advice? It sounds almost like “be one with the car” type of advice, yeah? No, not really. This one has meat on its bones. What it means is that when cornering, maximise the tyre traction. To extract the maximum amount of traction from the tyres is to maximise the area of the tyre traction circle. We discussed tyre traction circle in the car set-up section in the previous chapter. For your convenience, I have included below the tyre traction circle diagram, again.



During the pre-entry *hard braking phase*, the force vector should be pegged down to the bottom of the traction circle. You can achieve this, if you can extract the full amount of drag force from the tyres by applying the maximum force on the brake pedal, without locking up the wheels. You are now using all of the tyres' traction capacity for deceleration, so the force vector is on the rim of the circle.

But if all of the tyres' traction capacity is used to decelerate, they have nothing left to give to make the car turn. So, as you turn in, say to the right, you must reduce the retardation forces, so that the traction capacity can now be split between deceleration and cornering. To achieve this, we ease up on the brake pedal, as we turn in. And if we do not reduce the pressure on the brake pedal, we would lock up the wheels. So, this is a happy coincidence. We called this turning-while-braking technique trail braking, earlier. In the *trail braking phase*, the residual drag force and the newly appeared centripetal force combine to give the resultant force vector that traces an arc from the bottom to the right side of the traction circle. Improper trail braking leads to corner-entry understeer. Corner-entry understeer is a common complaint among the drivers. Perhaps the most common cause of corner-entry understeer is not a bad set-up, but the driver who carries excessive speed into the corner. The remedy is simple: choose a proper corner entry speed. And when a good driving technique is used in conjunction with a well-balanced set-up, the driver is able to choose a higher corner entry speed.

Here is a top tip. To find the right corner-entry speed, start by entering the corner at a slower speed than that which your instinct would allow. If you can turn in without any drama at that speed, then increase the speed a little, say by 10 km h^{-1}, and drive through the same corner again. Gradually raise the corner-entry speed, until you begin to feel the onset of understeer. The speed a smidgen shy of the last run is the proper corner entry speed. When watching a televised F1 practice session, you may see even the top drivers go off track, here and there. This is because they are using the practice sessions to discover the outer limits of traction at various corners, under different fuel load and on different tyre compounds. You will not see such shabbiness during the qualifying session and the race, because by then these clever coves have got the track sussed.

In the *neutral throttle phase*, the drag force disappears, and only the centripetal force remains, since you are now only turning right, and are neither accelerating nor decelerating. Hence, the resultant force vector points to the right. The harder you corner, the farther the force vector extends. If you use all of the tyres' traction capacity to turn, the force vector will be on the rim of the traction circle. If not, it will be inside the circle.

Then, when you begin accelerating in the *initial acceleration phase*, you must start unwinding the steering wheel, in order to split the tyres' traction capacity between cornering and acceleration. The residual centripetal force vector and the newly appeared thrust vector form the resultant vector that moves along an arc from the right side to the top of the traction circle. Drivers also frequently complain about corner-exit understeer, but the most common cause of that particular ill is the driver who begins accelerating energetically, while the steering wheel is still cranked. If you commit this error, the front tyres lose traction, and corner exit understeer ensues. The cure is to straighten the steering wheel first, before accelerating. Another favourite complaint of the drivers is corner-exit oversteer. Again, the most likely cause of this power-on oversteer is the driver who mashes the throttle in hope of reaching full throttle as soon as maybe, thereby delivering a surge of power to the rear wheels, thereby breaking loose their tyres. Because the car is still cornering, a snap oversteer results. So, a light touch on the throttle pedal is essential.

Finally, in the *hard acceleration phase*, you are no longer cornering, so only the thrust force remains. Hence, the force vector now points straight up at the top of the circle. If you accelerate at the limit of the tyres' traction capacity, the force vector will reach the rim of the traction circle. If you do not, the vector will be inside the circle. And if you exceed the traction limit, you get wheelspin.

In real life, we do not have an easy, direct way of measuring and displaying tyre traction circle. But a multi-axis accelerometer, also called a g-meter, makes an adequate substitute. Even a low-cost accelerometer that comes with a typical smartphone suffices for this purpose.

To sum up, if you are smooth with your hands and feet throughout the cornering sequence, you would have maximised the area of the tyre traction circle, and would have traversed the corner at the maximum possible speed. In theory, that is. In practice, you will have to contend with load transfer. So, read on.

throwing the weight around

Cornering traction may be improved by managing load transfer. Too much load transferred onto a suspension compresses it beyond its design limits. Too much load transferred away from a suspension extends it beyond its design limits. A deranged suspension, be it in compression or extension, cannot keep the wheel vertical to the track surface. In that case, the contact patch of the tyre shrinks, as the wheel tilts farther away from the vertical. Small contact patch means reduced tyre traction. Low traction means low speed.

There is more bad news. If too much load is transferred to one corner of the car, that corner dips down, and the diagonally opposite corner lifts up, because the car body is a rigid structure. Now, both these suspensions are deranged. And if the fast extension damper of the unladen suspension is stiff enough, the suspension would raise its wheel off the track surface, altogether. So, excessive load transfer is bad in more ways than one.

Although you cannot prevent load transfer, proper driving techniques can influence when and how much load transfers to which corner of the car, thereby mitigating excessive load transfer. For instance, shifting a bit of load at a critical time onto an unladen wheel whose tyre is on the verge of losing traction can mean the difference between maintaining control and spinning off the track. The reason why this works is because the transferred load presses the unladen wheel back onto the track surface just enough, so its tyre regains partial traction. Conversely, shifting some load away from a heavily laden wheel improves its traction, because the suspension is able to restore the wheel back to a more upright orientation. Hence, shifting the load along the longitudinal, lateral, and diagonal axes of the car redistributes the amounts of tyre traction among the four tyres. That means it is possible indirectly to affect the car's oversteer-understeer balance by managing load transfer, to some extent.

That is swell, but what sort of controls have you, as a driver, at your disposal to influence load transfer? Very few, actually. Once you are out on the track, the only controls available to you are the steering wheel, the foot pedals, the handbrake lever, the in-cockpit brake bias lever, and a few fragments of prayers you learned at Sunday school.

A consumer-grade racing wheel, like the G25, does not provide an analogue handbrake lever. So, on simulators, the handbrake is typically operated using a digital button. It is impossible to feather the handbrake using an on-off switch. Some PC-based simulators, including Assetto Corsa, allow assigning an analogue joystick axis as the handbrake.

Since S2U does not support an analogue handbrake lever, and since S2U's implementation of handbrake button leaves much to be desired, the handbrake is as good as useless to us, here. As for in-cockpit brake bias adjustment, you can certainly slide it forward or backward in between corners, so as to affect the way the car handles at the upcoming corner. This is what the modern F1 drivers do, in fact. But reserve that technique for later, when you have gained more driving experience. And of the three pedals, the clutch pedal is used only during gear shifts. What of the prayers? Well, you may wish to save those for times when you have totally lost control of the car.

So, the controls you have available to affect the car's instantaneous load transfer are the steering, the throttle pedal, and the brake pedal. Very few controls, indeed. So, it comes down to the driving techniques to influence load transfer, using only these few controls.

Oversteer and understeer have two causes: mechanical (car-induced), and biomechanical (driver-induced). When we discussed car set-up, we saw how to remedy oversteer and understeer, while the car is still in the pit. Here, I shall talk about the driving techniques that can mitigate oversteer and understeer, when the car is already out on the track. You need to know these driving techniques, because set-up alone is inadequate to cope with every form of handling ill. Moreover, a car that was well balanced at the start of the race can turn downright nasty mid race, due to weather change, track condition deterioration, tyre degradation, fuel burn off, a minor damage from an earlier collision, etc. The driver needs to be able to cope with these changeable situations.

Cures for oversteer: While on track, there are a few things you can do to cure oversteer: counter steering, lifting off the throttle, and increasing the throttle.

You can *counter steer*—that is, apply opposite steering lock—to keep the front of the car in line with the rear that is raring to step out of line. You must modulate the throttle pedal pressure, simultaneously. Indeed, this is how you four-wheel drift through the apex, the technique described later in this subsection.

And you can *reduce the throttle* to forestall rear wheelspin. Reduction of power to the rear wheels allow their tyres to regain traction, thereby avoiding wheelspin. With traction restored to the rear tyres, the oversteer is avoided. Lifting the throttle slows you down, of course, but it is preferable to spinning out.

Counter-intuitively, you can also *increase the throttle* to forestall oversteer. When you feel that the rear of the car is about to step out, instead of lifting off the throttle, you may try increasing the throttle slightly to accelerate the car. All you need is that little surge of forward thrust to transfer a small amount of load to the rear, thus restoring traction to the rear tyres. Even if the rear tyres are just barely hanging on, increasing the throttle works, sometimes. And I do emphasise sometimes, because this technique does not work in all circumstances. When it works, you power slide gracefully through the corner. When it does not work, you spin out, bringing shame upon your family, friends, and sponsors. Note that in a real race car, you sense the onset of oversteer through the seat. On a living room simulator, the only way you can sense oversteer is through the steering wheel and the cockpit view. As such, it is admittedly more difficult to perform this technique on a simulator than in a real car. But unless you try, you will not acquire the requisite experience that informs when you can push your car thusly, and when not. So, give it a go.

Cures for understeer: Unlike the oversteer situation, you have several driving techniques at your disposal to cure understeer, while on track: right-foot lifting, rocking the steering wheel, left-foot braking, manhandling the car, Scandinavian flick, and handbrake turn.

If the car understeers slightly at the corner, apply the *right-foot lifting* technique I mentioned earlier in this chapter. You are in effect applying engine braking, thereby transferring a small amount of load to the front wheels. This little bit of transferred load gently presses the front wheels back down onto the track, restoring just enough traction to their tyres. The understeer is thus mitigated. You are, in a sense, paying down the understeer with some speed.

So, what is the difference between right-foot lifting and reducing the throttle, the technique mentioned earlier? The actions involved are the same, but how they are used, when they are used, and why they work are different. Right-foot lifting is used to mitigate corner-entry understeer, whereas reducing the throttle is used to cure corner-exit oversteer. When right-foot lifting, you are applying engine braking to transfer load to the front, so that the front tyres gain extra traction. When reducing the throttle, you are reining the rear tyres back from the verge of wheelspin, thereby restoring traction to them. To keep things straight, I gave two different names to the same sequence of actions, depending on their uses and effects.

Another thing you can do is to *rock the steering wheel*, gently. To do this, start by turning the steering wheel, as you normally do to enter the corner. When you feel the steering wheel goes light, this is the front tyres' way of signalling to you that they are at the onset of understeer. Now, instead of lifting off the throttle, you unwind the steering wheel just a little bit, and immediately crank it on again, also by a small amount, until you sense the onset of another understeer. Repeat this rocking motion to achieve the desired amount of direction change. With this back-and-forth movement of the steering wheel, you are taking the front tyres up to the limit of their slip angles, and then back down again, never pushing the tyres beyond their limit. This allows you to maximise the centripetal force generated by the front tyres, thus alleviating understeer. But be smooth and incremental; if you rock the steering wheel violently, you will induce body roll oscillations, and perhaps even bring about an oversteer.

For a more prominent understeer, use *left-foot braking*, another technique I mentioned earlier in this chapter. To perform left-foot braking, gently dab the brake pedal with your left foot, without lifting your right foot off the throttle. The severity of the understeer determines the amount of brake pedal pressure required. The amount of brake pressure is proportional to the extent of the load transfer, and of course the amount of speed loss. In this technique, too, you are trading a spot of speed for a touch of traction. That you need not lift your right foot off the throttle is advantageous, when driving older, turbocharged cars, like the Lotus 98T and the Sauber Mercedes C9 LM. All turbocharged cars suffer from turbo lag to some degree. Even modern cars, with their multi-stage turbochargers, are not entirely free of turbo lag. By staying on the throttle, either partially or fully, the exhaust gases continue to spin the turbine, thus mitigating or eliminating turbo lag, when accelerating out of the corner.

If you car understeers chronically like a lorry, you have a few options: manhandling the car, Scandinavian flick, and handbrake turn.

On grippy surface, try *manhandling the car*—forcing the car to submit to your will. You perform this manoeuvre by pitching the front wheels hard toward the apex with a smart crank of the steering wheel, and by simultaneously loosening the rear drivewheels with a bit of extra throttle. The front wheels need to bite first, or this technique will only aggravate the already-extent understeer. So, transfer some load to the front with right-foot lifting or left-foot braking, just before you manhandle the car. If the rear end wants to over rotate, check it by counter steering and by modulating the throttle. If done right, the car would rotate readily, and would already be pointing at the exit, even before it reaches the apex, so you can get back on the throttle sooner.

This technique is also known as four-wheel drifting, because all four wheels beautifully drift sideway during this manoeuvre. Did you notice that four-wheel drifting can cope with both the oversteer and the understeer conditions? Yes, this technique is versatile. Master it.

So, what is the difference between the manhandling technique and the counter steering technique? The actions involved are the same. But the former refers to the cure for a corner-entry understeer, whereas the latter to the cure for a mid-corner oversteer. Here, again, I gave two different names to the same sequence of actions, depending on their uses and effects. And four-wheel drifting is the umbrella term that refers to the combined result of manhandling at the entry of the corner and counter steering through the remainder of the corner.

Grand Prix cars of the 1930s were ill-tempered beasts. Their savage engines generated way more power than their dainty little tyres could accept, and their suspensions were unequal to the task of keeping the tyres in contact with the track. As such, these cars understeered when entering corners, and oversteered when exiting corners. Four-wheel drifting cured both ills: manhandling pacifies corner-entry understeer; and, because the driver is able to get back on the throttle earlier, he has more time to smooth out his return to full throttle, thus mitigating corner-exit oversteer. Great drivers of that era, like Tazio Nuvolari, put this technique to good use on their way to the podium.

On a loose surface, however, a subtler technique—the *Scandinavian flick*—is better suited, because aggressively manhandling the car will only worsen understeer by breaking loose the front tyres. To perform this manoeuvre, start by entering the corner on a line that is slightly toward the inside, instead of on the conventional, outside line. Slow the car down as usual. While modulating the brake pedal, flick the steering wheel to the outside of the corner, and immediately yank the steering wheel hard toward the apex. At the same time, come off the brake, go back on the throttle, and four-wheel drift out of the corner by counter steering. Constantly adjust the throttle and the steering amounts to keep the car on the cornering line.

We may analyse the car's behaviour during the Scandinavian flick as follows. After the initial flick, the car is pointing away from the apex, leaning down on the front springs, especially on the inside-front. In this slightly askew, nose-down attitude, the front tyres are biting well, and rear tyres are raring to break loose. The subsequent, hard yank back toward the apex releases the pent-up energy stored in the compressed front springs. This sudden release of stored energy, together with a controlled throttle-on oversteer, swings the rear end out. A well-timed counter steer, then, drifts the car through the apex. Intuitively, this is akin to how an angler flicks the rod backward, before snapping it forward to cast the rig, far.

While in a four-wheel drift, modulate the throttle to control the rear end's attitude, and use the steering wheel to align the front end with the rear end, so as to keep the car straight on the exit line. This technique is even more effective in a car equipped with the flappy-paddle gear shifters, because you may then use left-foot braking, and you need not reposition your hands and feet to change gears during the manoeuvre. An appreciable amount of practice may be necessary to master this manoeuvre. Pay attention to every detail: where to enter the corner, when to flick the car away from the apex and by how much, when to fling back toward the apex, when to release the brake, how much throttle to give, and how much to counter steer. Corner characteristics may dictate how you execute the manoeuvre, too. If performed well, the speed, the fun, and the sense of accomplishment you get are well worth the effort of practising.

In sharp hairpins, use *handbrake turn*. Although you may use the handbrake turn to cure an understeer, it is a bit too crude for that use. Instead, it is better suited to spin the car round a very tight turn. Indeed, it is an oft-used technique in rallying to go round tight hairpins. As the car enters the corner, crank the steering wheel smartly toward the apex, and simultaneously squeeze the handbrake, then release it right away. Applying the handbrake seizes up the rear wheels, and snaps the car into oversteer. An immediate counter steer keeps the front end aligned with the rear end that swung out. You may return to the throttle, as soon as the car has spun round the apex. Think of the handbrake turn as a more extreme form of manhandling. In my experience, the only simulator that implements handbrake turn satisfactorily is Richard Burns Rally.

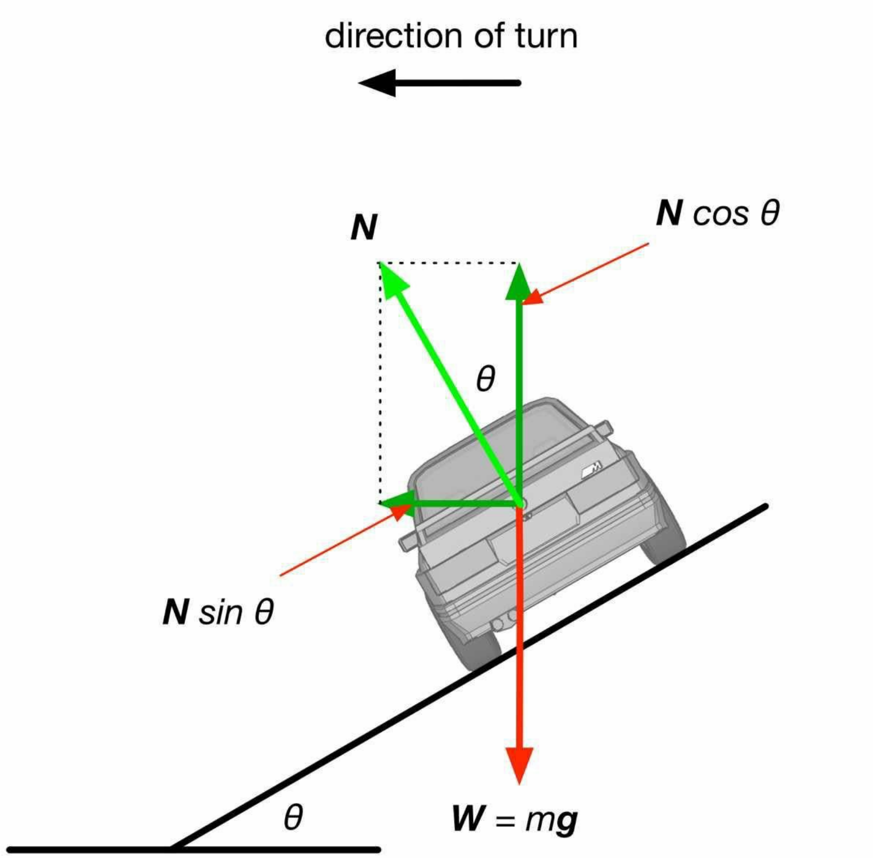
To sum up, wheel and pedal inputs affect load transfer. Load transfer affects traction capacities of the tyres. The difference in traction between the front tyres and the rear tyres affect the oversteer-understeer balance of the car. Hence, by applying proper driving techniques, we manage load transfer and overcome handling problems that crop up during a race, provided the car is set up well enough to begin with.

In the early phase of your learning, analyse every lap you drive. Make full use of the telemetry apps and different camera angles, when analysing your lap in replay. Seek out ways to improve your driving technique. Do realise that your car is subject not only to your commands, but also to several external factors—weather conditions, aerodynamic disturbances from nearby cars, and corner configurations (layouts, bumps, dips, banking, slope, dust, rain, and the like).

exploiting the terrain

The crowned surface was a common feature on older tracks, because it was the primary means of conveying rainwater away from the track surface. The *inside of the crown* provides a small, but appreciable, speed advantage to the attentive driver, who recognises and exploits this subtle terrain feature. Newton's Third Law of Motion is what causes the cornering speed to increase on a banked track.

In the diagram below, mass m of the car exerts a downward force $\boldsymbol{W}$ on the track surface under the influence of gravitational acceleration $\boldsymbol{g}$, and the track pushes back with an equal and opposite normal force $\boldsymbol{N}$, which acts perpendicularly to the track surface. The track is banked at an angle of θ. So, $\boldsymbol{N}$, too, is angled from the vertical by the same amount. Its horizontal component, $\boldsymbol{N} \sin \theta$, pulls the car to the inside of the corner, adding to the centripetal forces the tyres generate. This horizontal component is the reason why the cornering speed increases, when the corner is banked inward. All things being equal, the steeper the bank angle, the stronger this inward-pointing horizontal component, and the faster the cornering speed. Naturally, there are practical limits to how steep the banking can be made.



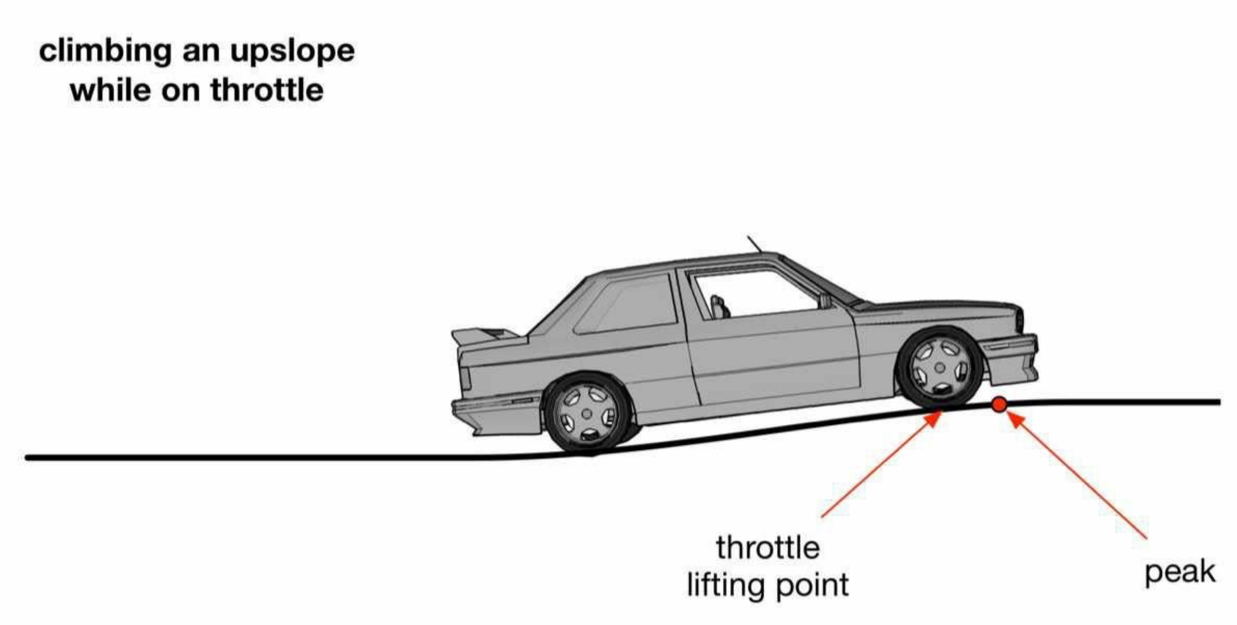
There are other ways terrain features can help increase speed. Sometimes, *mounting the kerb* at the apex with the inside-front wheel, if the kerb is low, helps rotate an understeering car, because the scalloped surface of the kerb tends to grab the inside-front tyre. If the kerb is high, though, a more delicate method of *nudging the kerb* is the thing to do. Here, too, we are taking advantage of the friction between the side of the tall kerb and the inside-front tyre. This calls for a near-perfect precision in placement and timing. Taking too much kerb will launch the car off the kerb, or worse damage the inside-front suspension. And if there is no kerb at the apex, let the inside-front wheel drop off the track just a little. This also works, if there is a depression at the apex of the kerb. By *dipping into the depression* with the inside-front wheel, we are essentially pivoting the entire car about this wheel. This technique is often used in rallying.

Some corners are littered with marbles, off the racing line. Marbles are bits of rolled up rubber shed by the tyres, as the cars brake and accelerate at the corner. The rolling tyres sweep the marbles off the racing line, so the racing line is generally clean. But if you misjudge the corner and run off the cornering line, you can add significant loss of traction to your woes, because racing tyres lose adhesion on marbles, gravel, dust, and other debris. Once you are on the marbles, no fancy driving can save your dignity. On the other hand, if you and your opponent enter the corner side by side, and if you manage to occupy the clean racing line, he would be obliged to stray onto the marbles. Advantage you.

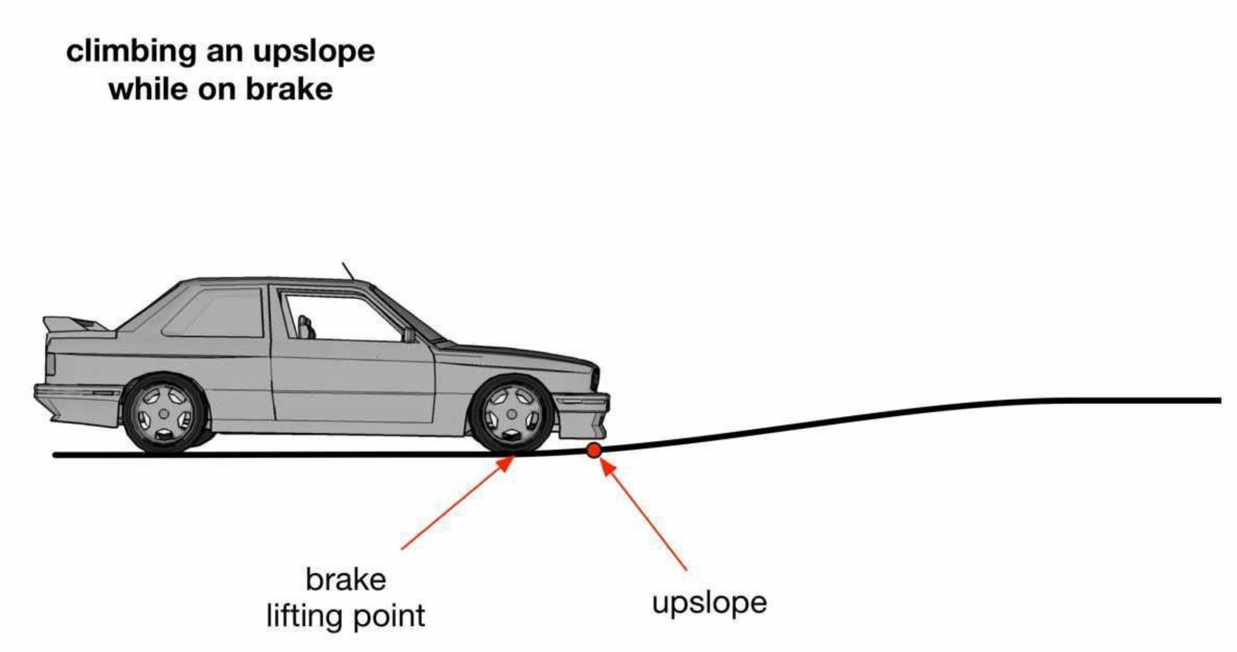
Most circuits have track surface irregularities such as waves, ripples, bumps, dips, and potholes. They tend to upset the car's suspension, and cause handling problems. If the undulations are very close together, you may be able to *skip over the ripples* at a fast enough speed, provided the car's suspension and your body could tolerate the abuse. This is analogous to skipping a stone over the tops of the ripples on a pond.

On the other hand, if the undulations are larger and are farther apart, they resemble a wave. If you try to skip over a wave at speed, the crest of the wave may lob the car into the air. Instead, you must *ride the wave* like a surfer. A wave is a series of gradual, but deep, bumps and dips. A bump is an upslope followed immediately by a downslope, and a dip is the inverse of a bump. So, the problem reduces to driving over an upslope and a downslope. The important thing when riding a wave, is to keep the car steady in both attitude and direction. To put it simply, do not allow the tyres to lose contact with the track surface, by launching off the ledge. It goes without saying that your suspension set-up must be soft enough to follow the terrain, yet stiff enough for the driver to maintain control. So, let us see how we can ride the upslope and the downslope.

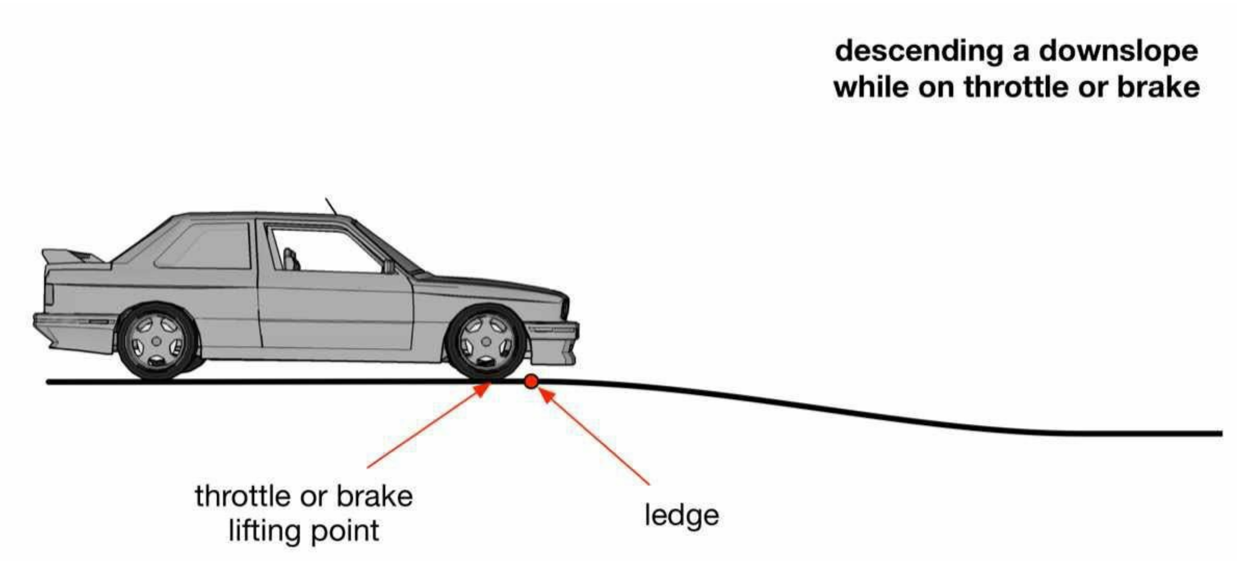
If you are on the throttle as you come upon an upslope, remain on throttle while you climb up it. When the front wheels are just about to crest the peak, ease up on the throttle pedal, slightly. Be smooth. You are now employing a little bit of engine braking. This slight retardation transfers some load onto the front wheels at the critical moment, thus preventing them from launching off the peak. Consequently, they follow the profile of the peak, as they roll over it. Once the front wheels have passed the peak, you may return to throttle. Had you remained on the throttle as you crest the bump, the car will launch off the peak, and take flight. Then, when it slams back on the terra firma, it will be in a ripe mood. The diagram below shows the point at which you should lift off the throttle, just before cresting the peak.



If you are hard on the brake as you approach an upslope, the front suspension is already compressed close to its compression limit, due to load transfer. In this condition, if the front wheels encounter the upslope, the rising track surface pushes them further into compression. This can bottom out the front suspension at the worst possible moment. To avoid this negative outcome, ease up a bit on the brake, just before the front wheels encounter the upslope. This transfers some load away from the front suspension. The front wheels are now better prepared to meet the upslope, because the front suspension has gained a bit more wiggle room. You may immediately return to braking as soon as the front wheels are on the upslope. The diagram below shows the point at which you should lift off the brake, just before you reach the point where the upslope begins.



When descending a downslope while on the throttle, ease up on the throttle a bit just before the front wheels reach the ledge, where the level track surface ends and the downslope begins. This will transfer some load onto the front wheels and keep them planted, as they follow the profile of the track, and roll down past the ledge. If you had remained on throttle, the car will launch off the ledge. Once the front wheels are on the downslope, you may return to throttle. The diagram below shows the point at which you should lift off the throttle, just before you reach the ledge of the downslope.



When you approach a downslope while on the brake, the rear wheels are unloaded. If the car descends the downslope in this precarious state, the rear wheels will lose traction. The car will then spin, and slide down the slope, backward. So, ease up on the brake, just before the front wheels reach the ledge. You may return to braking, once the front wheels have passed the ledge, but you must continue to modulate the brake pedal pressure as you descend the downslope, in order to avoid a snap oversteer. The diagram above shows the point at which you should lift off the brake, just before you reach the ledge of the downslope.

The wave-riding techniques I described above are not really cornering techniques, nor are they exploiting the terrain so much as they are enabling you to cope with it. However, if you master these techniques, you can attack your less enlightened opponents while their cars are unsettled by the track undulations in the braking zone at the entrance of the corner. So, in that sense, they are the cornering techniques that allow you to exploit the terrain.

race strategy

A race can be viewed as solving a multi-constrained optimisation problem that minimises lap time, track distance, and resource consumption. If you finished a lap in a shorter duration than your opponents, you are at the top of the time sheet. If you take the shortest path round the track, your lap time will be the shortest. And if you drove smoothly and managed to conserve your resources like fuel, brakes, and tyres better than your opponents, your car will be the freshest and the fastest at the end of the race. On the other hand, if you go flat-out on every lap, hoping to minimise lap times, you will consume the resources faster than your opponents, and will suffer in the end. And if you take the shortest path without regard to corner characteristics and track conditions, you will lose time, instead of gaining. So, what you need to do as a racer is to optimise time, distance, and consumption, so as to enable you to cross the finish line, first.

Of course, this is a gross, over simplification of the relationships between time, distance, and consumption. In reality, countless variations are possible. You may choose *more pit stops* than the others, yet you managed to win. How? One possibility is this. You take on less fuel at each pit stop, so your on-track time between stops is necessarily shorter. Because you plan to log fewer laps than your opponents between stops, you can take on less fuel, and choose less durable soft tyres. Lighter car on softer tyres yield faster lap times. So, you win the race, despite having gone though more pit stops, provided of course that the pit lane is not too long that the lengthy time you spent traversing the pit lane negates the time advantage you built up on the track.

An opposite strategy is that you employ *fewer pit stops* than everyone else. You take on more fuel at each stop, and you chose harder tyres. But because you waste less time in the pits, you win. This strategy works well if the track's pit lane is very long, the track surface is smooth so it does not chew up the tyres, and the harder tyres possess a good balance of durability and performance. A twist on this strategy is that you managed to stretch the service life of the same tyres your opponents were using, because you *drove more smoothly* than all of them.

Sometimes, a few drops of rain is coming down on a part of the track, but the rest of the track is bone dry, and the weather forecast indicates that the rain will be blown off and fair weather will return in just a few minutes. In this situation, if the damp part of the track has no standing water, and if you have *good car control*, you may choose to stay on dry tyres, while the rest of the field switch to intermediate rain tyres. Not only do you save time by forgoing a pit stop, your dry tyres are much more durable than softer rain tyres, as well.

On a tight and twisty track, you may not be able to overtake a train of slower cars. Then, you may wish to *pit early to escape the congestion*, and if you time the pit stop properly, you come out onto a clear track. You can then pull out several fast laps on fresh tyres, thus gaining time on your opponents.

A few drivers, like the great Michael Schumacher, are able to drive a competitive race at a level of effort well below the maximum. That is, they can maintain similar lap times, while they *hold in reserve* skills and supplies, which can be called up on demand. These drivers can pull out a couple of fast, in-laps on used tyres just prior to the pit stop, and a couple of fast, out-laps after the pit stop on fresh but cold tyres. These few fast laps may add up to a second or more, which is all they need to maintain the lead and to win the race.

So, which strategy works for you depends on loads of factors: your abilities, your driving style, your strategist's experience, your mechanics' efficiency in servicing you in the pit, your opponents' strengths, tyre compounds available, pit lane length, pit lane speed limit, track configuration, crashes, weather, and many, many more.

Most simulator users drive short races of about ten or twenty laps at a maximum. Since race strategy becomes a significant factor only at longer races with sixty or seventy laps, and since a correct strategy can only be chosen after a detailed, real-time assessment the opponents' performances, a lone simulator user cannot be a strategist, an engineer, and a driver, simultaneously. So, I shall say no more about race strategy. I included this short section to provide you a background on race strategy. This will give you a better appreciation of what the real-life, top-tier, teams are doing behind the pit wall, next time you watch an F1 race on the tele.

I shall conclude with a few tips on conservation of resources, which are driving techniques that relate to race strategy. Even in short races that are only five or ten laps in duration, you will come out ahead, if you conserve your resources better than your opponents. If you drive smoothly, you use less fuel and you lengthen the tyres' service life. Because you use less fuel each lap, you can carry less fuel quantity than your opponents, thus making your car lighter. A lighter car is easier on the brakes and the tyres. It also accelerates, decelerates, and corners faster than heavier cars, so you lap faster. And because your smooth driving puts less stress on your tyres, they remain fresher than those of your opponents, toward the end of the race. You can then flip a switch on, as it were, and sprint to the end, as your opponents flounder about on worn-out tyres. You may even lap a second or two faster than your opponents by the end of the race. So, being smooth goes a long way. By *smooth driving*, I mean the following:

- Set your car up properly, so that you would not have to manhandle it into corners. Then, you will be able to save your tyres for the sprint at the end of the race.
- When entering corners, avoid mashing the brake pedal. If you can feel the onset of wheels lock-up, you can take appropriate remedial actions to avoid flat spotting the tyres. This will save your tyres and the brake pads, especially at the front end of the car.
- When coming out of corners, do not mash the throttle pedal. Accelerate quickly, but gradually. This avoids spinning the drivewheels, thus conserving the rear tyres. Being smooth with the throttle will also save fuel. Be kind to your engine; at upshifts, listen carefully to the engine sound, and avoid hitting the rev limit.

Tail-out driving that smokes the tyres may look impressive to the uninitiated, but it is not fast. Being smooth with the steering wheel and the pedals is the key to speed. Be smooth. Be boring. Be fast. Be the winner.

on-track tactics

Tactics are the mano a mano manoeuvres you employ against your opponent to gain or retain an on-track advantage. I present here offensive manoeuvres and defensive manoeuvres.

Offensive manoeuvres: The most important offensive tactic is overtaking—the essence of racing. To overtake an opponent in a comparable car, you may need to stay close behind him for a lap or two, learn his weaknesses at different sectors on the track, and attack him when he is at his weakest. This is called *stalking*. You must be able to spot the strengths and weaknesses of your opponents, and compare them against your own. Some cars are fast on the straight, but they are hopeless in the corners, and others are quite the opposite. Some opponents are slow in one part of the track, perhaps because their cars are ill suited to that sector. Some computer-generated opponents habitually commit errors at certain points on the track. So do some human opponents.

While stalking, try to characterise what type of opponent he is: the oblivious, the timid, the belligerent, and the nervous. The oblivious ones merrily go round the track, and pay no notice to who is coming up from behind. The timid ones will swerve away, if you come up from behind and show your nose next to them. The belligerent ones will knock you silly, if you try anything of the sort. And they may even shoulder you off the track, while attempting to seize the inside line. The nervous ones get agitated easily, when you follow them closely, and signal your intention that you mean business. Once they have become unsettled, they start to make mistakes—a lock-up, a wheelspin, or an overshoot, here and there. After following a bloke for a lap or two, you tend to get a good reading of his predilections, aversions, strengths, and weaknesses. Now, you are in a position to prevent him form taking advantage of his strengths, and to exploit his every weakness.

Do take care not to fixate upon the target in front, when stalking; monitor the mirrors to keep tabs on those behind you who are raring to pounce, if you leave an opening. Maintain situational awareness at all times. And if you cannot pass an opponent after trailing him close behind for a couple of laps, your engine and brakes may begin to overheat, due to lack of cooling airflow. At this point, you may have to pull back a bit, to give your car a chance to recover.

Another thing to keep in mind when you are close behind an opponent is aerodynamics. Modern race cars, especially the single-seaters, are very sensitive to downforce. When you are tucked in behind an opponent, your car is in his draft—a partial vacuum that forms behind his car. That means your wings are not working at their peak efficiency, and they may even be stalled. So, a significant portion of the downforce is missing, when you are in his draft, but his wings are working normally, because his car is travelling through the undisturbed air. If you try to turn with your opponent while you are in his aerodynamic shadow, you will experience a severe understeer, because your front wings are producing very little downforce. As such, you will lose a lot of time against your intended victim.

Here is another noteworthy point about stalking an opponent. I have heard one too many real-life racers who, after the race, bemoan how close they got to the leader at the corners, and if only they had a few more laps, they could have won the race. Perhaps. But more likely than not, this perception of catching up to the leader is an illusion. The proper way to analyse the situation is to examine the time delta, not the distance gap. If the follower is 1 s behind the leader on the straight going at 300 km h^{-1}, the distance between the two cars is about 80 m (300 km × 1000 ÷ 3600 s), almost the length of a football pitch. At the hairpin where the speed drops to 30 km h^{-1}, the same 1 s time delta yields a distance gap of 8 m. Hence, the follower closes the distance to the leader at slow corners, especially when the leader has already slowed for the corner, but the follower is still at speed. But because the time delta remains the same, the follower will never actually catch up with the leader. So, when you are stalking an opponent, do not be persuaded by the apparent closing of the distance; instead, judge your performance based on the time delta. In a real-life F1 car, the time delta appears on the steering wheel display. In AC, you may run the timing and scoring app, while in the cockpit view, to see the time delta.

Now, let us examine the mechanics of overtaking. As you come out of a corner that leads onto a long straight, tuck in as close as possible behind your mark. When your nose is snuggled up to his exhaust, you will have to lift off the throttle partially, in order to avoid bumping into him. At this point, he is at full throttle, but you are not, because by being in his aerodynamic shadow, you are protected from the air resistance, but he must face the air resistance, head on. So, you are holding an advantage, because you have a throttle reserve, and because you face less aerodynamic drag. Driving in tandem at a very close proximity like this is called drafting.

The *drafting* manoeuvre works as follows. As the nose of a speeding car pierces the air ahead, the air molecules scamper out of the way, and glide over the car's contoured skin. This smooth airflow adjacent to the skin is called the laminar flow. Upon reaching the boot lid at the rear of the car, however, the molecules are abruptly and unceremoniously toss overboard. This abrupt transition disturbs the laminar flow, and turbulence forms immediately behind the car. This trailing region of turbulent air is a few car-lengths long. It is a powerful, partial vacuum that sucks in the surrounding air mass. The car that created the wake vacuum, too, is being pulled back into it, by the power of the vacuum. This is how the aerodynamic drag arises. Hence, a car at speed has to contend with both the resistance of the air mass ahead and the drag of the vacuum behind. You can experience this by holding your hand out the window, as you drive. Do it in a safe place, though.

Once you are can creep up to within a few car lengths behind your opponent, your car begins to get sucked into his wake vacuum. As the vacuum pulls in your car, your speed increases slightly, so you are able to creep up and tuck in behind him. When your bonnet is within a few metres of his boot, your car is not only shielded against air resistance, but also is pulled forward by the vacuum. In a sense, your car is being towed by your opponent. So, you can now ease up on the throttle, and let him do the work for you. Do not feel bad for him; he, too, is benefiting from your drafting. When you are drafting behind him, both cars experience only one car's worth of air resistance at the front (his), and wake drag at the back (yours). So, both cars move more efficiently, when drafting together. This is why several cars draft together in a train, on American-style large ovals.

As the car in the draft, your advantage is that although both of you are travelling down the straight at the same speed, your opponent is using all his engine power but you are holding back some in reserve. The victim (draftee) has but one defence against his attacker (drafter)—the draftee, upon noticing that he is being drafted, can dodge (step aside), thereby denying the drafter of the advantage afforded by the wake vacuum. But an alert drafter will simply tuck back in. And if the defender dodges multiple times, he could appear to the race stewards as though he is attempting to block the attacker. So, dodging is hardly a worthwhile defence.

Note that even if your intended victim is in a slower car ahead, you can still draft behind him briefly on the straight to gain a bit of extra speed, and overtake him right away, without waiting until you reach the next corner entry. The speed gained from this *slingshot* manoeuvre may be slight, but it is an advantage, nonetheless.

Your disadvantage as the drafter, however, is that your forward vision is largely obscured by the car ahead. So, you must look past your opponent's car and seek out the reference points of the upcoming corner.

On the approach to the next corner, sneak out from behind him, and apply full throttle to accelerate past him. Your opponent is defenceless at this point, for he is maxed out on engine power. Thereafter, brake for the corner, and occupy the inside line into it. This is called the *late braking* manoeuvre. If you time the manoeuvre precisely as though you are delivering the punch line to a good joke, your opponent will be forced to take a non-optimum line through the corner, and you will be able to accelerate away from him out of the corner, laughing at your own joke, as you chase down your next victim. Do give a courtesy nod to the poor fellow, though. Using a combination of drafting and well-timed late braking, you can even overtake a slightly faster car.

Defensive manoeuvres: As mentioned above, dodging is an ineffective defence against drafting. But there are a few things you, as the draftee, can do to defend your honour.

If a drafter botched the timing and comes out of your shadow too early before the pair of you reaches the next corner, you can tuck in behind him, and *return the favour*. Now, the table has turned, and you are the drafter, and he the draftee.

And you have an effective defensive manoeuvre against an aggressive, late-braking attack. As the two of you approach the corner, he is still in your draft. He does not have a clear view of the braking reference point, but you do. So, you can delay braking until the very last moment. Because he does not want to pull the trigger too early, he may grit his teeth, and choose to stay in your draft. But if he stays in that spot too long and slips out just a bit late, he will miss his braking point, and carry excess speed into the corner. All you need do is to let him pass on the inside, because you know he will soon slide off the racing line, and will end up on the marbles. But you are on the optimal line at a proper entry speed. Once he is mired in the marbles, you can slip back inside him, and speed away from him out of the corner. This defence is sometimes referred to as the *over-and-under* manoeuvre, because the defender was on the outside (over) line into the corner, but is subsequently on the inside (under) line out of the corner. These are the elements that spice up a race.

A less respectable, but equally effective, defence is to *slam the door* on the attacker, right at the apex. When the attacker is a bit timid and failed to seize the opportunity to occupy the inside line into the corner, the defender may well chop across the attacker's bow, and cut back onto the inside line at the apex. This manoeuvre, more often than not, leads to a crash. So, use your judgement.

Fairness and courtesy: When you are on the track, be decisive and avail yourself of every opportunity. But be fair. And extend all courtesies due to your fellow racers. During a race, one driver has as much right as any to occupy a spot on the track, provided someone else is not already there. In property law, there is a principle called "first in time, first in right." It states that he who possesses a thing first has superior rights thereto. Applying this principle to racing, we can say that if a driver has already occupied a line through the corner, do not stick your nose between him and the apex. Respect each other's rights. Give each other room to race. Races are long, and they offer plenty of opportunities. You can afford to forgo one or two opportunities to protect your car and your reputation against harm.

Similarly, if you choose to defend against an attacker by dodging, use this manoeuvre only once. For example, as you lead your opponent toward a corner, you may step to the inside line just before entering the corner. This will force him to take the outside, less optimal, line, so this is a valid defence. But if you cocked up your timing and defended too far from the corner, your opponent will simply tuck back in behind you, and draft past you on the outside line. In such a case, it would be unseemly for you to step back onto your original line to defend the second time. If you dodge more than once, it is considered *weaving*, or perhaps even *blocking*. Neither is fair nor legal.

Also, do not slam the door too late on your opponent. If your action led to a crash, you would be deemed to have caused an unavoidable collision, and will be penalised for the offence.

As a driver seriously trying to master racing, you may be tempted to join the on-line races. Good to you, then. I encourage you to race on-line, but only after you have mastered the driving techniques and you are consistently defeating your simulated opponents. But be forewarned. A majority of your on-line opponents are there to have fun, not to learn. So, do not become frustrated, when you get punted off the track. Never give up.

There once was a time when it was possible to divide racing simulators into two categories: realistic and arcade. These two categories of simulators served users with divergent goals. The solemn drivers who sought the thrill of car racing chose the expensive, realistic simulators, and the jolly ones who enjoyed banging about opted for the arcade types. There was a foreboding peace between the two camps, as one did not intrude upon the other's turf.

But with the advent of inexpensive console-based simulators in the recent years, the drivers and anti-drivers now regularly collide in on-line races, one group focused on racing by the rules, the other intent on mayhem, thus giving rise to all sorts of calamities. Of course, enforcing an accurate damage model will eliminate this thorny issue. As that is not the case at present with S2U, we must coexist with obstreperous arcade gamers.

There is a wide range of misbehaviours exhibited on track by these gamers. The most common one is ramming opponents off the track from behind, using a fast, high-PI car. Some people like to saunter up next to the intended mark, and turn suddenly into the victim, thereby spinning the victim off the track. Then, there is pouncing, where one lies in wait round a blind corner, and slams into passers by. A variant of this is planting the car on the racing line at a blind apex. Poor chaps who blunder into the corner at speed invariably slam into the back of the parked car and bounce off the track, or they try to avoid the parked car in panic and spin off the track. Another popular technique is weaving, where someone in a powerful car equipped with super-sticky tyres weave side-to-side in front of a line of cars, ramming off the track anyone who dares try to overtake him. You can count on a few things: these blighters predictably misbehave; they all drive the fastest cars; they almost never spin because they have every available driving aid turned on; they have superior situational awareness because they drive in the hateful bird's eye view; they will drop out of the race, if they are outmatched; and they will predictably avoid a race restricted to helmet view.

In general, you should avoid going head-to-head against those who drive heavily upgraded cars and possess near-perfect winning ratios, because more likely than not they attained such phenomenal winning percentages through mischief. And the power-limited Group D races are better for serious on-line racers. But beware of a situation where a miscreant hosts a Group D race to ensnare fair-minded racers in low-powered cars, then surreptitiously switches to a Group A race and a higher-powered car, moments before the start of the race.

But there is a potential benefit to racing against these zealous gamers—use them to hone your anticipation and avoidance skills. Indeed, accidents occur even in real life, professional races. So, learn to anticipate the behaviour of the other drivers, and time your control inputs to avoid those roving obstacles.

specialised techniques

In this section, I shall present a number of specialised driving techniques: endurance racing and night driving.

endurance racing

There is an aspect of online racing that the popular simulators on the market today do not support: endurance racing. Endurance races are several hours long, some even last a full 24 hours, like the 24 Heures du Mans. The Le Mans race starts at 16:00 on a Saturday in May, and finishes at 16:00 the following day. By the end of the event, each car, driven by a team of three drivers, would have clocked in over 5,000 km. The rules prohibit a driver from driving more than four consecutive hours. Most drivers would drive two-hour stints. So, a typical roster is two hours on, and four hours off. Some drivers go two consecutive stints, if they feel fresh enough. Only the best and the healthiest can partake in endurance races. They are gruelling.

For a simulator to support endurance racing, a driver must be able to communicate and coordinate with his team mates, so that they can work out who takes a turn on the track, for how long, and when. And a driver must be able to hand over the same car in the pit, with whatever damage it suffered on track, to one of his team mates. I doubt consumer-grade simulators would ever support an online endurance racing feature.

But any simulator capable of online racing can host something akin to an endurance events, with the aid of an external coordination means like a voice communications server. There are, of course, logistical problems that cannot be overcome, such as sharing the same car, damages and all, among the team drivers. But if the participants are honest and collaborative, online endurance races could be simulated. Or perhaps you are feeling particularly macho, and you decided to drive for four straight hours on a track, all by your lonesome. I implore you to use caution and sense, before you drive in a multi-hour session. Hours sitting in the racing seat and pushing and pulling on the little steering wheel can cause repetitive strain injury. Please do not hurt yourself.

night driving

Night driving is an essential skill in endurance and rally racing. Often, the tracks are not well lit, if at all, so the only reliable light source the driver has is the headlights of his car.

Real-life night driving in the context of endurance or rally racing is—how shall I say it—different. A track that you are thoroughly familiar with, the one that you have run countless day races, looks and feels like a strange, new track. And your body clock is running out of phase with the sun. Moreover, the cold air and the cold track surface alter the performance characteristics of the engine and the tyres.

Night racing emphasises a different set of skills, too. You become much more attuned to the sound and the feel of the car. You rely more on your sense of timing, because in some corners you cannot see even the reflective paint covered kerbs, let alone the trackside reference objects. Reduced vision means reduced speeds. So, if you are a well-practised driver with an impeccable timing and an unimpeachable muscle memory, you can maintain a consistently higher speed than the rest of the field during the night by compensating the reduced vision with your other, non-visual senses. The danger is that if you are so far ahead of the pack, you may well be alone, out ahead. This can bring on boredom and lapses of concentration, followed shortly by crash, injury, and death, usually in that order, unless you died of boredom, first.

CHAPTER FIVE — LEARNING THE NORDSCHLEIFE

overview

Before you can drive fast on The Ring, you must know every centimetre of the track. When you see a corner from a cockpit view, you should be able to name the corner, identify its visual reference points, know where its apex is, and recall where the bumps, dips, and crowns are. Moreover, you must be able to recall the names of the corners before and after this one. And it would help, if you can see this corner on the map, in your mind's eye. The only way to acquire this level of familiarity is by driving the track, over and over. But you cannot drive on the track, because you are yet unfamiliar with it. This is indeed a knotty problem.

To untangle this knot, you have to start somewhere. A good starting point is to take in a bit of its history: who the designer of the track is, when was it constructed, in which part of the world it is located, how many corners it has, what the names of the corner are, how the corners got their names, and so on. Make the track your friend, as it were. And then, there is a truly bad way to start learning a racetrack: hop in the car and pound round the track, hoping all will be well, in time. Do not do that.

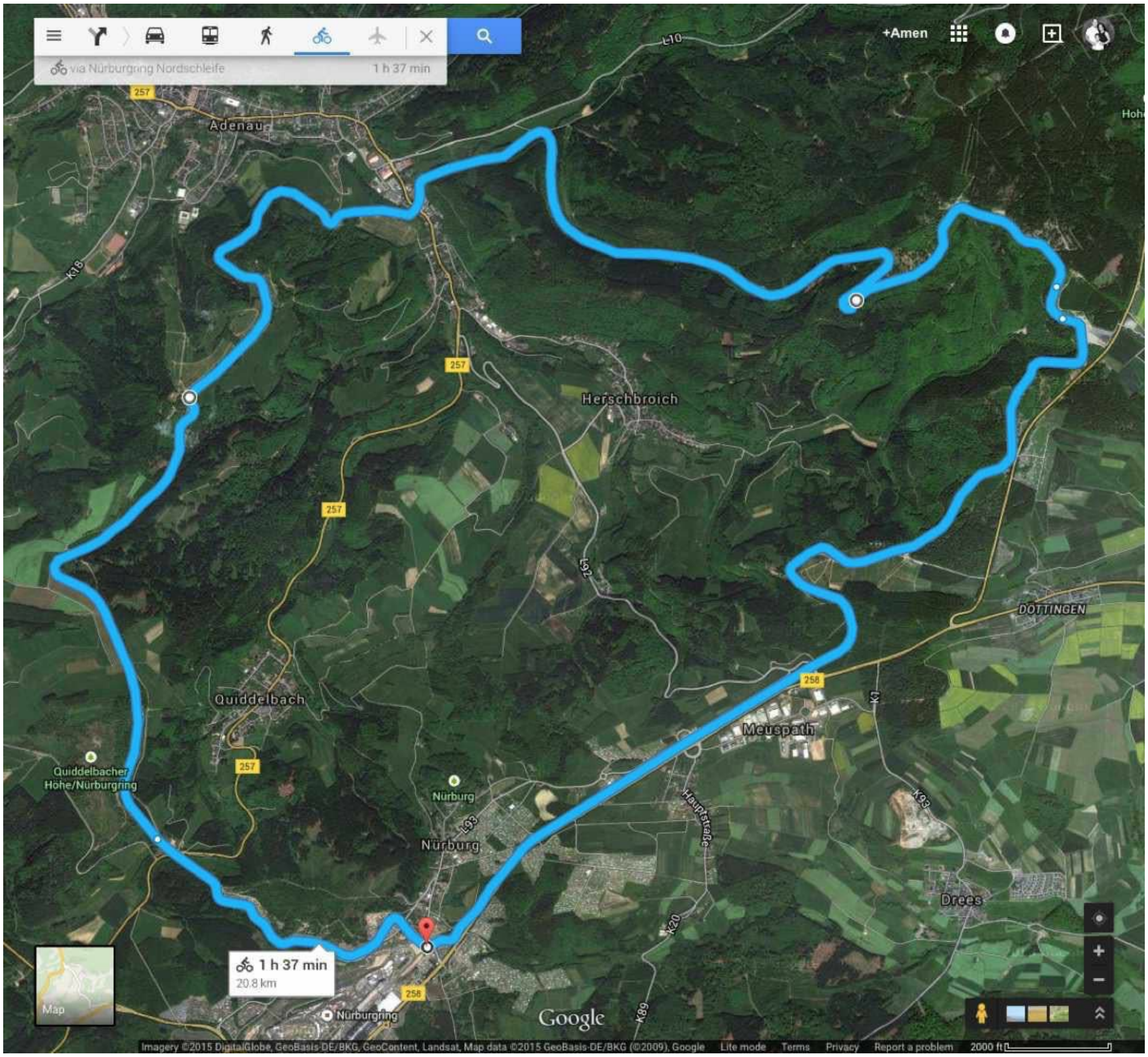
So, let us begin with a little background history. Construction of the Nürburgring began in 1925 and was completed in 1927. The track encircled, and still does, the medieval village of Nürburg in Western Germany. The twelfth century castle still stands tall atop a hill, and is clearly visible when rumbling down the long straight, Döttinger Höhe. The original Nürburgring comprised of the Nordschleife (northern loop) and the Südschleife (southern loop). Together, they were referred to as the Gesamtstrecke (combined track). Remnants of the Südschleife can still be seen on the satellite map below. But it is no longer possible to highlight the exact path the original Südschleife took, since the area where the two loops joined had been modified extensively over the years.

The original layout had a slender section called Start und Zielplatz (start and finish place) that connected the two loops. After the demise of the Südschleife, this bit became the Südkehre (southern bend), a hooked-tail section to the Nordschleife. This short straight was where the old starting line and pits were located. The modern F1 circuit, called the Grand-Prix-Strecke, was built on top of the Südkehre between 1982 and 1983, so the old section is no longer visible in the satellite image.

Unlike the Südschleife, the Nordschleife has remained largely unchanged through the years. Today, the Nürburgring comprises the Nordschleife plus the Grand-Prix-Strecke along with their myriad configurations. The Nordschleife is the track upon which Grand Prix legends like Rudolf Caracciola, Tazio Nuvolari, Juan Manuel Fangio, Sterling Moss, Jim Clark (my favourite driver), Jackie Stewart, and Niki Lauda raced. And this track hatched a respected Ring Specialist Sabine Schmitz, literally, for she grew up in the village of Nürburg.

The Nürburgring comprises the following four configurations: the 5.1 km Grand-Prix-Strecke F1 circuit, 19.1 km Touristenfahrten, the 20.8 km Nordschleife, and the 25.4 km Gesamtstrecke. The German Grand Prix F1 race is held on the *Grand-Prix-Strecke*. Tourists and weekend warriors drive the *Touristenfahrten*, when there are no scheduled races. They enter the track from the car park along the Döttinger Höhe straight, but the lap starts under the Bilstein bridge just before Antoniusbuche, and ends under the Audi gantry just after Galgenkopf. So, the tourists must drive slowly along the Döttinger Höhe straight, where the professionals normally go full speed. Car manufacturers set their lap records on the *Nordschleife*. And the VLN 24-hour endurance race is held on the new *Gesamtstrecke* that combines the GP-Strecke and the Nordschleife.

To most enthusiasts, however, the name "Nürburgring" is synonymous with the Nordschleife configuration, the track that traces the old Nordschleife, excluding the pendent Südkehre. In 1983, the late Stefan Bellof, driving his Porsche 956 Group C Le Mans prototype race car, set the current fastest lap time of 6:11.130. The Nordschleife, shown below, is the object of our obsession.



via Nürburgring Nordschleife
1 h 37 min
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1 h 37 min
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Map
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Imagery ©2015 DigitalGlobe, GeoBasis-DE/BKG, GeoContent, Landsat, Map data ©2015 GeoBasis-DE/BKG (©2009), Google Lite mode Terms Privacy Report a problem 2000 ft

learning aids

The Nordschleife, The Ring, is frightfully long. The number of corners is maddening, and many of which have blind entries. The elevation changes are extreme. The scenery is beautiful, yet disquieting at the same time. The level of concentration required to drive just one lap is unrivalled by any modern racetrack. Over its 80-year history, many racers have made regular pilgrimage to this track, yet only a few have risen to the rank of Ring Meister. But there is a long list of Dead Ringers, who have paid for the privilege of driving on it with their lives. And there are scores of enthusiasts like me, who scurry about in the safety and comfort of living room simulators. This chapter, I hope, will cast a spell upon you and transfigure you into one of us—a Ring Worm.

To drive The Ring at speed, you need to know just about every centimetre in intimate detail—the sequence of corners and straights between them, the layout of each corner, the line, the bumps, as well as the trackside references. Not only must you know each corner by sight from the cockpit, you must also recognise it on a map or in a satellite image, so that you can maintain a mental map of where you are on the track at all times. And you should be able to close your eyes and visualise all the corners in their proper sequence. The task of learning the track on simulators is made more challenging by the fact that every simulator models The Ring slightly differently, visually and physically. The good news though is that once you have learnt the track on one simulator, the visual and muscle memories carry over to another simulator.

Note that there is much confusion as to the precise number of corners on the Nordschleife, because some bends are rather slight and a number of them merge to form larger sections. The count depends on whether the counter considers a slight bend a corner. The matter is further muddied by the numerous configurations, bygone and current, all bearing the designation "Nürburgring." In this book, we are concerned only with the 20.832 km Nordschleife configuration, which is generally accepted as having 154 corners.

Start by learning the corner names in German, and simultaneously associate the name with the satellite view, as well as the cockpit view. I published on my YouTube channel numerous replay videos of my Nordschleife hot laps, recorded in Shift 2 Unleashed, rFactor 1, rFactor 2, and Assetto Corsa. All of these videos are annotated with the corner names.

nordschleife

Let us now lap The Ring in a stock BMW E30 M3. Along the way, I will describe in detail the named corners and the racing lines through them, and show how they look from the cockpit of a race car. Remember though that the braking point, turn in point, and gearing I suggest here are specific to S2U's modelling of the stock M3 and the Nordschleife. If you upgrade this car, drive a different car, or choose a different simulator, you must account for the differences and adjust your driving accordingly. Note also that I will be using an unofficial numbering scheme, such as Hatzenbach 1, Hatzenbach 2, etc., for descriptive convenience.

Unlike on a modern F1 track where a name refers to the actual corner, a name on the Nordschleife refers to a section that comprises a sequence of corners and the short stretches of track that string them together. S2U divides Nordschleife into the following three unofficial sectors:

- Aremberg sector — Antoniusbuche to Adenauer Forst
- Karussell sector — Adenauer Forst to Caracciola Karussell
- Nürburg sector — Caracciola Karussell to Antoniusbuche

First, learn these sectors individually in this order. Drive at an easy pace, and take in the scenery: the trackside objects, the bumps, the dips, everything. As you grow more familiar, increase speed. But note these old, familiar corners will look and feel differently at racing speed, especially at night.

Once you have learnt them all, practise on the Nordschleife proper until you can lap the entire track without making major errors. Learn the track in the car set-up testing mode if you are tuning the car, or in a one-man race if you are seeking XPs. Do not race against multiple opponents, right away.

aremberg sector

Aremberg sector starts in the middle of the Döttinger Höhe straight, and ends just after the Adenauer Forst complex. This starting line location matches the Touristenfahrten configuration in which the lap starts under the Bilstein bridge. But on the full track, Nordschleife configuration, the start-finish line is located at T13. In this section, we shall designate the T13 start-finish line as the 0 km mark.

Döttinger Höhe is certainly one of the longest straights on any racetrack. On the right about halfway down the straight is the car park and the track entrance used by the weekend warriors who aspire to conquer the Nordschleife. The black overhead signs in the image below mark this entrance from the car park. Remember, though, that these signs do not appear on the real Nordschleife.

Every screenshot in this section has a mini map in the lower-right corner. The red dot indicates the approximate location of the car on the map, when the screenshot was captured.

Antoniusbuche—Antoniusbuche marks the end of one of the longest straights in motorsports, Döttinger Höhe. This bend is the fastest bend on The Ring, because its curvature is so slight that it may be taken at full speed in top gear (5th in the M3). So, although it is a name bend, think of it as a continuation of the Döttinger Höhe straight.

The apex of this corner is just beyond the Bilstein bridge. The track rolls downhill starting at the bridge, and the crest of the hill obscures your view of the apex when approaching the bridge. The apex becomes visible only after you passed under the bridge. So, use the bridge as the visual reference, and initiate turn in just before you reach the bridge. In the image shown below, the car is moments away from initiating the left turn. Clip the apex at full throttle without mounting the kerb. At this speed, mounting the kerb will upset the car so much that it would rebel against you, and that could be harmful to your health.

Note that S2U models this portion of The Ring differently from other simulators. In every other simulator I know, the hump under the bridge is severe enough to do the car some mischief. In those simulators, it may be necessary to lift the throttle just a bit as the car passes under the Bilstein bridge. But in S2U, even a wingless E30 M3 can blithely glide over this hump.

At the exit of this bend, let the car wander to the right side of the track, in preparation for the corner ahead.

Tiergarten (20 km)—As you crest the hill at Antoniusbuche, shift your gaze to the next corner, Tiergarten. The 20 km mark is along this downhill stretch, just past the Bilstein bridge. The consensus line through Tiergarten can be seen in the image below as a dark streak veering left to the distant. Stay on the right side of this short straight as you approach Tiergarten.

Tiergarten is a quick, left-right kink. Stay in 5th gear at full throttle through the left (first) kink. You may clip the kerb as shown in the image below, but do not mount it. Upon reaching the right (second) kink, stand on the brake pedal, and begin descending down the gears using the heel-and-toe technique. Do not forget to modulate the brake pedal pressure, in order to avoid locking up the wheels.

Hohenrain Schikane—You will be entering Hohenrain Schikane almost immediately after you exit Tiergarten. Continue stepping down the gears until you reach 2nd gear, the cornering gear for this chicane. S2U marks the apex of many corners. The apex of this one is marked with a blue overhead sign on the lift side of the track, as can be seen in the image below. Other simulators are not so generous.

There is a road that enters the chicane from the left. You can go beyond the white line that marks the left edge of the track, and borrow that little patch of tarmac at the entry further straighten the right-left exit portion of the chicane. Remain in 2nd gear, as you accelerate out of the chicane. After exiting, stay to the left side of the track.

T13 / Start-Ziel (0 km)—T13 complex is where S2U places the start-finish line for its Nordschleife configuration. The complex includes a right- and a left-hander. Initiate an early turn in for the right-hander, just as you pass the grey concrete patch off to the left shown in the image below. This concrete patch and its kerb are slippery, so take care not to slide onto them as you position the car for the right-hander. And remember, you are still in 2nd gear. When you take the corner, valiantly aim for the Armco barrier on the right, because the apex is at the base of this barrier. Imagine that you are scraping the Armco with your right wing mirror. At the turn-in, use a dab of left-foot braking to make the front wheels bite. Do not over rotate the car, or you will spin out.

Beyond the steel gantry in the image above lay the front straight and the pits of the Grand-Prix-Strecke. If you were running the 24-hour endurance race, instead of taking the T13 right-hander, you would be going straight through under this gantry onto the Grand-Prix-Strecke. The Start und Zielplatz of the old Gesamtstrecke used to be located in that vicinity, as well.

As you accelerate out of the right-hander, swing toward the blue barrier on the right side of the track. The start-finish line is just ahead, at the top of the rise. This is the 0 km mark for the Nordschleife configuration in S2U. By the way, the kilometre distance marks cited in this book refer to the Nordschleife configuration shown in the above track map. On this map, the 0 km mark is drawn at the Start-Ziel (start-finish) line. But on the real track, the 0 km mark is at the track entrance gate located on the Döttinger Höhe straight. So, my distance references do not match up with the kilometre marker boards erected on the track. I chose to follow the track map's fictitious distance marking scheme, because under this scheme, the 0 km mark coincides with S2U's start-finish line.

Just prior to going over the crest at the start-finish line, begin braking and heel-and-toe downshift into 1st gear. Note that the downhill slop will make the rear end light and skittish under hard braking. And that little patch of tarmac on the right, which is visible in the image below, may seem inviting, but avoid it because it is quite slippery.

because the downhill slope makes even a well-balanced car understeer, badly. The dark streak in the image below is the consensus line through this left-hander. Be sure to stay on it.

As you accelerate out of T13 left-hander, the track bends slightly to the right. This bend has no name, but in the Porsche 997 GT3 RS video, this bend is labeled The Bogen. Stay in full throttle through this bend, and swing to the left side of the track. By now, you should be up in 4th gear.

Hatzenbach (1 km)—Hatzenbach is a long series of left and right flicks that demands precision and rhythm. It is one of my favourite sections on The Ring. The entry to the complex is a deceptively fast right-hander, which you take in 4th gear. At a bend with a high-speed entry, even a well-balanced car will understeer initially, because the high speed tends to push the front wheel to the outside of the corner. So, turn in early, and stay inside the crown. Of course, how early you turn in depends on how much speed you are carrying, how heavy your car is, and how well you had set up the suspension. It may also be necessary to manhandle the car or to apply a touch of left-foot braking to ameliorate understeer. Try playing with the tyre slip angles by rocking the steering wheel, as well. My favourite technique is to turn in early and manhandle the car into Hatzenbach 1 in 4th gear at full throttle. But the timing and placement must be very precise, or you will understeer off into the Armco.

Use whichever combination of techniques work for you. If you cannot control this high-speed understeer and miss the apex, you will get on the slippery bit, and the high speed will carry you off the track. Note also that the racing line is quite bumpy at the apex, which means you may not be able to return to throttle as early as you may wish. In the image below, you can see the racing line through Hatzenbach 1 as a dark streak curving to the right, as well as the apex marked by the blue overhead sign. Hatzenbach 1 is the southernmost point on the track.

The stretch between Hatzenbach 1 and Hatzenbach 2 is where many of your computer-generated opponents will slide off, so be prepared to seize the opportunity. As far as I know, consumer-grade simulators do not implement adaptive AI for drivers, where the AI engine learns from the opponents' behaviour and adapts its tactics to the situation. So, you tend to have predictable opponents, when racing on simulators. S2U is no different. Thank goodness for on-line racing against human drivers, yeah?

In the image below, three cars committed errors at Hatzenbach 1, and are now wallowing in the weeds. The lead car made the same mistake, but has already recovered and is back on the track, and is well on its way to Hatzenbach 2. In just a few seconds, the driver of the red E30 M3 (the one whose helmet view the screenshot shows, and yes it was I who was at the wheel) will overtake the two trailing cars and secure the third position. Depending on how much speed you carried through Hatzenbach 1, you may be shifting up to 5th gear, soon.

The next bend, Hatzenbach 2, is a fast left-hander. The apex is marked by the black overhead sign, as shown in the image below. You may forego clipping the apex, and drift directly to the braking zone on the right, because a sharp left flick is coming up ahead. But a number of computer-generated opponents, having made a proper cock-up of Hatzenbach 1, will slide wide, far to the right at Hatzenbach 2, as well. If you time it right, you can sneak under them on the inside line and drift out to the right, thereby preventing them from mounting a comeback at the next corner.

As you approach Hatzenbach 3, get on the brake hard and heel-and-toe down through the gears to 2nd gear, as soon as the plush, red-and-white crash barrier appears through the gap between the Armco barriers on the left. The braking point is approximately where the car is in the image below. The said crash barrier is barely visible.

Hatzenbach 3 comprises a sharp, slow left, followed immediately by a right. Sacrifice the left flick by mounting the kerb as shown in the image below, so as to straighten the right flick. The right flick can be seen just ahead in the image below. Protect the inside line into the right flick, because some aggressive computer-generated opponents may try to inject their nose between you and the apex of this right-hander.

In the image below, the car is just about to clip the apex kerb of the right flick at the exit of Hatzenbach 3. This is a high kerb, and mounting it will upset the car, which will create trouble for you at the next corner, which follows right away. In a badly understeering car, you may wish to nudge your right front wheel against this high kerb at the apex and throttle up, simultaneously. The drag at the right front wheel and the slight loss of traction at the spinning rears mitigate understeer and helps rotates the car. Modulate the throttle and be prepared to counter steer, in order to forestall oversteer that may arise from unintended over rotation. Remain in 2nd gear.

Some of your opponents will stumble here. They typically loose their rear end and spin into the red-and-white crash barrier on the left. Some recover, but the loss of traction slowed them down appreciably. Pounce.

Hatzenbach 4 is a right-left flick. Its entry actually blends in with the exit of Hatzenbach 3. So, it is more efficient to take this pair of right flicks as a double-apex right-hander. Coupled with the fact that Hatzenbach 3's entry left flick is rather sharp, it makes sense to sacrifice it, as we did. In the image below, the car has just clipped Hatzenbach 3's right flick, and is approaching Hatzenbach 4's right flick, with the left flick visible just ahead. Accelerate and shift up to 3rd gear.

In the image below, the car is clipping the apex of the left flick at the exit of Hatzenbach 4. Remain on the left side of the track after exiting, and stay in 3rd gear. The orange banner ahead marks the apex of the next corner.

Hatzenbach 5 is a right-left flick. You can take it in 3rd gear in your stock E30 M3, if you manage to retain speed trough the previous corners. It is the last corner of the complex. Remain on the left side of the track as late as possible, dab the brake pedal with your left foot, turn sharp right, and mount the kerb on the right as you go under the orange banner. This will buy you an extra few centimetres of track. Since you are in 3rd gear, every little bit helps to carry speed through the turns. Although this kerb is high at this right flick at the entry of Hatzenbach 5, the speed is slow enough and a sufficient amount of weight is transferred to the left, so the suspension can absorb the shock without fuss.

When you see the second orange banner at the exit of Hatzenbach 5, sharply turn left and place the car on the inside of the crown of this left flick. In an understeering car, you may need to manhandle it to keep the car on the line. If you miss the apex, you will drift off onto the exit kerb on the right. This kerb, which is under the second orange banner, is high enough to spin the car round to the left, if you accelerate hard while the right rear wheel is still on it. In the image below, the driver has just initiated the turn into Hatzenbach 5's left flick, having just seen the second orange banner peeping out from behind the trees. The car is at the 1 km mark, now. This bit is another bane of many a computer-generated opponents. They tend to overcook the left flick and slide unceremoniously onto the high kerb on the right. If you properly insert the car onto the crown here, you can crush your opponents with abandon. Accelerate out of the Hatzenbach section, but remain in 3rd gear on the short straight that follows the exit. Remain on the right side of the track.

This description of Hatzenbach is perhaps longer than necessary. I took the trouble to inject this much detail here, because it is easy to lose track of where one is in these many, visually similar left-right flicks in the Hatzenbach complex. If executed correctly and precisely, this long section is where you make up ground on your opponents, both the biological and the silicon variety. And this section is loads of fun to drive. It is all about rhythm—proper timing and coordination of all the control inputs.

Hocheichen—Hocheichen is tricky. It looks like a sharp right-hander from the approach, but the crest at the apex of the right-hander hides a rather pronounced left kink that immediately follows.

When approaching Hocheichen, stay in 3rd gear. And instead of shifting over to the left edge of the track to take the right-hander, as you would normally, remain on the right side of the track. A moment after passing under the orange banner at the exit of Hatzenbach, begin slowing down using a touch of left-foot braking. But do not slow down too much. Once you reach the cornering speed, come off the brake. Now, flick the car to the left side of the track, and subsequently crank the steering wheel toward the apex of the right-hander. The rear will want to come round, so control it by counter steering and by modulating the throttle. The car will drift beautifully through the corner. Clip the apex of the right-hander with your right front wheel. And if timed right, the left wheel will be poised to clip the apex of the left-hander that immediately follows, without too much steering input. Begin accelerating right away, and clip the left apex. This is one of the corners where the Scandinavian flick works well. Since a long straight follows this corner, it is vital that you carry speed through this corner. The Scandinavian flick allows you to do just that. This manoeuvre is tricky, for sure. Timing and smoothness determine success. So, practise. Practise a lot.

There is a danger here, though. The entry of the right-hander is adversely cambered, so it is easy to misjudge the turn-in point and understeer off to the left, thereby missing the apex and getting you into trouble at the left kink that suddenly appears on the other side of the crest at the apex of the right-hander. If you botched the entry, you would be obliged to slow down to recover. You would then be obliged to heel-and-toe down to 2nd gear, instead of taking the corner in 3rd gear. This robs speed and wastes time. You will pay for this loss of speed along the straight that follows.

In the image below, the car has just clipped the apex of the right-hander, and is at the top of the crest. The white kerb of the left kink protrusion is barely visible. If are in 2nd gear, shift up to 3rd gear as you come down the hill, and insert the car onto the inside of the crown of the left kink. If you had executed the Scandinavian flick correctly as described above, you would now be accelerating down the hill in 3rd gear. You are now heading north. You have just turned a corner, so to speak.

In the image above, note how the track drops away sharply to the left. A little extra speed you gained using the Scandinavian flick is amplified by this steep slope at the exit, and by the time you reach the end of the following long straight, the speed difference becomes appreciable. The reason is physics. Given the same amount of acceleration along a straight, staring with a higher initial velocity will yield a higher terminal velocity at the end of the straight. So, do not cock up Hocheichen. Indeed, be tidy like a nice little schoolboy scribing in his copybook, all the way from the entry of Hatzenbach to the exit of Hocheichen. You will reap the rewards in just a few seconds hence.

Quiddelbacher Höhe (2 km)—As you roll downhill out of Hocheichen, the track bends slightly to the right, just as it goes over a hump. This hump is the bridge where the track passes over the motorway 257. You will be up in 4th gear, by now. Right after passing the bridge, the track climbs back up a steep hill. This is Quiddelbacher Höhe, which is 2 km from the starting line. Charge up the hill on the left side of the track at full throttle in 4th gear. In a light, powerful car without wings, you may wish to lift the throttle just a bit before you reach the top of this hill. Otherwise, the car will go airborne, and depending on its aerodynamic characteristics, may slam back on the track in an unfavourable attitude. And if you attack the hill at full tilt on the right side of the track, the car will fly even higher. You will then arrive at the next corner, a fast double-apex right-hander, in a quivering car. In a fast car, you will have to jab the brake pedal upon landing, in order to settle the car before taking the double-apex right-hander.

With impeccable timing and precision, you can take this double-apex right-hander in 4th gear at full throttle in your stock E30 M3. But at this speed, you will have to manhandle the car at the first apex and counter steer mid corner, in order to point the car at the second apex. The crown is rather pronounced in this corner, so remain on the inside of the crown through the entire corner. To add to the challenge, there is a slight crest in the middle between the two apexes. In the image below, the car is clipping the first apex of the double-apex right-hander. The mid corner crest and the crown are clearly visible.

If you overcooked the first right-hander, you will slide over onto the opposite side of the crown, mid corner. Then, the adverse camber of the road will push you to the outside edge of the track, and make a mess of the second right-hander. Since the second right-hander leads to a high-speed, uphill stretch, the more speed you can carry through Quiddelbacher Höhe the better.

A number of computer-generated opponents will understeer all over this double-apex right-hander. If you time your entry precisely to occupy the inside of the crown, you can exact stiff punishment upon them.

Flugplatz—As soon as you exit Quiddelbacher Höhe, you are placed at the entry of Flugplatz. This section includes a series of three slight left kinks on an uphill-then-downhill elevation. The apex of the first left kink, Flugplatz 1, is at the top of a crest. It is flanked by four black flags, as shown in the image below.

The track elevation dips just barely between Flugplatz 1 and Flugplatz 2. So, Flugplatz 2's apex is also on a crest. Flugplatz 3 is at about the same elevation as Flugplatz 2, but the track drops away to the left at the apex of Flugplatz 3. Just before you clip the apex of Flugplatz 3, shift up to 5th gear. Note that the apex kerbs of Flugplatz 1 and Flugplatz 2 are painted in the usual red-and-white colours, but the apex kerb of Flugplatz 3 is unpainted.

Some of your opponents will understeer off to the right, mid corner. The thing to do is to draft behind them, as you approach these kinks, and as they understeer off toward the Armco on the right, sneak past them on the inside.

The track rises higher at the exit of Flugplatz 3. In the image below, the car has just exited Flugplatz 3, and the next hill is visible in the distant. Climb that hill on the right side of the track, while remaining in 5th gear.

Schwedenkreuz (3 km)—After the steep hill at the exit of Flugplatz, the track flattens out and bends to the left. This very fast left-hander is Schwedenkreuz. Heel-and-toe down to 4th gear with just a light jab at the brake pedal, clip the left apex, and stay on the inside of the crown, but avoid mounting the high kerb. There is a rather pronounced bump mid corner at Schwedenkreuz. Let the car glide over this bump first, before returning to full throttle. If you hit the bump at an excessive speed, you will get lobbed into the Armco off to the right. This mid-corner bump trips up some opponents. So, be ready to capitalise on their error. The image below shows the entry of Schwedenkreuz, moment before executing the heel-and-toe downshift. Remain on the left side of the track at the exit, instead of drifting over to the right. The car is now at the 3 km mark.

Aremberg (4 km)—As you approach Aremberg, heel-and-toe down to 2nd gear, while staying on the left side of the track. Turn in early. Hug the right side kerb as shown in the image below, because the corner is adversely cambered and there are marbles off the line on the outside of the corner. After turn in, get back on the throttle well before you reach the apex. So much for the pedagogical admonishment of clipping the apex at neutral throttle. In an understeering car, nuzzle the tall kerb at the apex with your right front wheel to help rotate the car. This little trick requires a deft touch. If the understeer is severe enough, you may even need to throttle up to jolt the rear wheels loose for a bit of extra help. Now, let the car drift out to the edge as you pass under the Yokohama bridge. Aremberg is the westernmost point on the track. The 4 km mark is just past the bridge. Getting on the throttle early is key, because a long downhill stretch follows this corner.

A few computer-generated opponents may try to insert themselves between you and the apex. Maintain a situational awareness by checking the mirrors regularly, so that you can avoid being bumped off the track. An opponent who claimed the inside line with injudicious exuberance will understeer massively, and will slide off to the left. Let him. The driver of the white car in the above image has just committed this error. As he falters, remain on the inside and secure the exit line by quickly drifting out toward the base of the bridge. This will keep him trapped on the kerb longer, and he will lose more time. That is how the over-and-under routine plays out. If you keep your cool and focus on the job, you can knock a few opponents out of contention by leaving them far behind.

Fuchsröhre—As you pass under the Yokohama bridge, shift up to 3rd gear. You can see in the distant a white flag and a black flag. The black flag marks the apex of the first left kink of Fuchsröhre. By the time you reach this apex, you will be in 4th gear. The track drops away at this apex into a downhill stretch, which is almost straight save for the slight right-left-right kinks. Somewhere on this downhill stretch, you will snick into 5th gear. Do not mount the kerbs at this speed. Here is a top tip. If your car understeers a bit at the kinks, time your upshifts so that you are off the throttle at the precise moment you need to clip the apexes. Because the throttle is off during the upshift, that causes momentary load transfers toward the front, thereby increasing front wheel traction and decreasing understeer.

After the final right kink on the downhill slope, the track bends slightly to the left and climbs sharply up a hill. In the image below, the car is about to take the second-to-last left-hander. The steep hill looks imposing. The final left-hander of Fuchsröhre is barely visible at the top of that hill.

The second-to-last left-hander at the base of the steep hill is perhaps the trickiest bit of the entire Fuchsröhre section. Its curvature is gradual, so you can take it in 5th gear at full throttle. But the track abruptly transitions from a steep downhill slope to a steep uphill slope at the apex of this corner. So, the car must negotiate changes in both direction and attitude while at top speed. And there is a big dip near the inside kerb, just prior to the apex. As the car comes down the hill at high speed and meets the sharp uphill slope, the front suspension suddenly compresses to near its jounce limit. In this state, the suspension will not be able to tolerate the additional punishment meted out by the big dip. So, if you take the inside line here, the big dip will probably seize the left front suspension, and deposit the car into the loving embrace of the Armco. And do not slam on the brake while the front suspension is operating at its limit, or the forward load transfer will seize up the front suspension, thereby causing you to lose directional control. Recovery will be difficult at best, given the high speed, the irregular surface, the steep slope, and the narrow track.

For these reasons, I suggest you go wide at the apex, a bit toward the middle of the track, where the surface is smoother. If your car has good brakes and if you have the iron constitution, remain in full throttle through the slope inflection at the base of the hill, and stand on the brake and heel-and-toe down to 4th gear, only after you have climbed up the hill and the front suspension is unloaded. If you prefer a more sedate course of action, however, lift off the throttle before you reach the base of the hill, coast up the hill with your foot off the throttle, then heel-and-toe down to 4th gear. Do not come off the throttle at the slope inflection point, or you will stress the front suspension further.

The computer-generated opponents will fall by the way side at the slope inflection point. They tend to slide off to the right. Time your arrival, so that you will neither be bumped by the cars sliding to the right nor be obliged to take the treacherous inside line.

The final left-hander on top of the hill is fast and blind. You can take it in 4th gear at near full throttle. Just be sure to settle the car while climbing up the steep hill, and initiate the turn-in, early. Clip the high kerb at the apex, but do not mount it. Remain on the left side of the track in preparation for the next corner, and heel-and toe down to 3rd gear.

Adenauer Forst (5 km)—The next right-hander, shown below, is the entry into Adenauer Forst. Take this right-hander in 3rd gear at a speed a little faster than your instinct may command. The faster the speed you carry, the earlier must the turn in be, in order to accommodate the power-on understeer. Be sure to stay on the inside of the crown shown in the image below.

After clipping the apex of the right-hander at the entry, heel-and-toe down into 2nd gear and swing to the right edge of the track. Get as close to the right-side kerb as you can, but do not mount it. As you slow down, turn in sharply for the left flick, remain in neutral throttle, and mount the kerb on the left, in order to widen the line for the next corner. The kerb will not harm the car at this slow speed.

If you are close behind an opponent as you come through the right-hander, you may be able to sneak past him and occupy the inside line at the left flick. In the image below, the driver of the blue car has veered off to the right as he prepares to take the left flick. The driver of the red car, the car in which we ride, is about to plant himself between the blue car and the apex of the left kink. The red car driver must necessarily forego the optimum line in this case. If the red car driver is overly aggressive, the blue car driver will counter attack at the last right-hander that comes immediately after the left flick using the over-and-under manoeuvre. You are now at the 5 km mark.

The last right-hander is adversely cambered, so the car tends to slide off to the outside of the corner. To remedy this, turn in earlier, and nudge the right front wheel against the side of the tall kerb. This kerb is shown in the image below. The resulting drag at the right front wheel helps rotates the car, and cures the understeer. By the time you come out of this right-hander, you will be in 3rd gear. Take care not to mount the exit kerb; it is high. Some opponents will understeer mid corner, here. If you dominate the inside line and accelerate early before you reach the apex, you can leave them in the dust. If you cannot overtake them at this corner, try to draft past them in the straight that follows. It is vital that you carry as much speed as possible through Adenauer Forst, because it is followed by a fast, downhill stretch.

karussell sector

Karussell sector starts on the straight at the exit of Adenauer Forst, and ends after Caracciola Karussell, the most recognisable corner on The Ring for its bowl-like steep banking.

Metzgesfeld—As you exit Adenauer Forst in 3rd gear, you can see the black flags and an overhead latticework that marks the start of this sector. The track bends slightly to the left after the black flags, and rises up a bit. Shift up to 4th gear as you clip the apex of that slight bend. Point the car to the right edge at the top of the crest.

When you reach the top of the crest, you will see a black advertising signboard behind a tall tree in a field on the left. This sign marks a left kink hidden behind the Armco. In the mid portion of the image below, you can see this black signboard peering out from behind the singular tall tree. Now is when you should start dallying over to the left. Clip the left apex in 4th gear at full throttle.

After clipping the apex, the track immediately drops away to the left. This fast left-hander is the entry into Metzgesfeld. Let us call it Metzgesfeld 1. Point the car to the right edge in preparation for the entry, left-foot brake, and turn in smartly, while staying in 4th gear. Do not place the right side wheels on the grass. If you do, the car will spin hard left across the track. Because the right wheels on grass have almost no friction, the car will pivot around the hard braking left wheels. It will be nearly impossible to recover from this snap oversteer, given the high speed and the steep downhill slope.

Then, as you aim for the left apex, be sure to place the car on the inside of the crown, or you will understeer off to the right. In the image below, the car is clipping the apex of Metzgesfeld 1. The aerial tower in the distant marks Metzgesfeld 2, which is another left-hander. As you exit Metzgesfeld 1, scamper over to the right side of the track and heel-and-toe down to 2nd gear.

The left-hander at Metzgesfeld 2 is tricky for a number of reasons: it is a slow corner, but the approach speed is rather high; the entry is on a fairly steep downslope; there is a protrusion on the right at the exit, which is hidden from view by the Armco at the apex, so you need to turn in sharper than you think you may need; there are marbles off the line on the right, which stand ready to ensnare you; and the track rises briefly at the apex, then drops precipitously at the exit, so the car gets light at the slope inflection point. The proper line through this corner is to turn in early to avoid the off-line marbles, and tighten the turn so as to straighten the line between the left apex and the subsequent right flick. Shift up to 3rd gear, as you exit. In the image below, the car is approaching Metzgesfeld 2. The aerial tower that marks the corner is partly visible ahead.

Kallenhardt (6 km)—The track plunges abruptly after exiting Metzgesfeld, as can be seen in the image below. This is where the 6 km mark is, and the corner ahead is Kallenhardt. The steep downslope helps acceleration, so by the time you reach the entry of the right-hander, you will be have gained quite a bit of speed. So, you will have to brake hard, and the rear of the car will get very light. Do not be aggressive with the brake pedal, or you will lock the rear wheels and will tumble down the hill like Jack and Jill.

Heel-and-toe down to 2nd gear, just before you initiate the right turn. Rotate an understeering car by nuzzling the right front wheel against the tall kerb at the apex. Do take care not to mount the kerb. As you accelerate out of Kallenhardt, shift up into 3rd gear, and continue the downhill plunge.

Spiegelkurve—As you continue the descent, remain in 3rd gear, and creep over to the right edge of the track, gently lift the throttle to transfer a bit of weight onto the front tyres for extra bite, and turn in. Position the car so that you can straight line this corner as much as possible, then drift out to the left edge of the track. In the image below, the car is at the entry of Spiegelkurve, having just initiated the turn in. The black overhead signs mark the left and the right apexes, both of which will be clipped as the car travels along a straight path.

There is a pronounced dip in the track surface at the left apex. Your stock M3 can skate over it without a flinch, but stiffly sprung cars may feel it more acutely.

Miss-Hit-Miss (7 km)—Next comes a long right-hander known as Miss-Hit-Miss, named after the proper line through this section: miss the apex of the first right-hander, clip the second, and miss the last. The entire sequence is taken in 3rd gear. Technically this corner is not a triple-apex right-hander, since you clip only the middle apex. All three apex kerbs are painted red and white, and they make tempting targets for your right front wheel. But you must resist the urge to clip the first and the third apex kerbs.

In the image below, the car is approaching the first right-hander. At this point, apply a touch of left-foot braking to help the turn in. Go wide to miss the kerb on the right. Because the apexes are hidden behind the steep side of a hill, you will have to practise this corner a few times at slower speeds, before you acquire the muscle memory to execute it properly without being able to see the apexes.

Apart from its odd line, Miss-Hit-Miss is a rather simple corner. But if you carry too much speed into it, you will understeer off into the Armco.

Swing to the right side of the track at the exit of Miss-Hit-Miss. You are now at the 7 km mark. Depending on your gearing, you may need to shift up to 4th gear, before you reach the next corner. To avoid this, consider lengthening the 3rd gear one click.

Wehrseifen—Wehrseifen is shaped like a shallow U (right-left-right), and it is a very slow corner. It is the closest thing to a hairpin turn The Ring has to offer. Before entering the first right-hander, heel-and-toe down to 1st gear and clip the right apex. The first half of the U start at this apex, and ends at the red-and-white crash barrier that marks the bottom of the U. In the image below, the car is clipping this apex, and the crash barrier is visible just behind the Armco.

Wehrseifen is tough to get it right. It is tight, like a proper hairpin. And a steep downhill braking makes for an excitable rear end. Its main, left apex is hidden behind the Armco, and is nib sharp. There is a big dip just before this apex on the inside line. And the outside line is slippery with marbles. The only help to be found here is the rather pronounced crown. Place the car on the inside of the crown, but not too close to the bumpy apex. The proper line through Wehrseifen can be seen in the image below as the dark streak.

Be forewarned. If you try to straighten the corner by widening the entry, your aggressive opponents will be more than happy to shoulder you off to the slippery bit, and occupy the narrow inside line. So, guard your left. Once you get past the left-hander, accelerate, shift up to 2nd gear, and clip the right apex at the exit of Wehrseifen. This apex can be seen in the image below. Note how the car stays on the racing line, away from the bumpy left apex. Shift up to 3rd gear, now.

Breidscheid—Continue downhill in 3rd gear, and clip the apex of the right kink at the entry of Breidscheid. Stay on the right edge of the track.

Then, just as you reach the little access road on the right, shown in the image below, heel-and-toe down to 2nd gear, and simultaneously manhandle the car sharply into the corner. Stay on the inside of the crown through the left apex, and remain on the left side at the exit. If you go over the crown, you will understeer onto the right side high kerb in front of the blue-and-white crash barrier. And if you accelerate hard while on this kerb, you will snap oversteer headlong into the Armco on the left.

The dip just past Breidscheid bridge is at 332 m above sea level elevation, and is the lowest point on The Ring. The track begins to climb up to the heights from here. Now would be a good time to don your oxygen mask. The uphill journey begins with a steep upslope, which is also a sharp right-hand turn.

Ex-Mühle (8 km)—While remaining in 2nd gear, turn smartly into the steep, uphill right-hander. Accelerate early, clip the apex, drift out to the left edge, and go up through the gears. This corner is bumpy, the camber is markedly adverse, the uphill slope is steep especially at the apex, and you are accelerating hard not just to gain speed but also to claw up the hill. This combination makes the car ticklish. You can oversteer on the crest at the apex, if you are injudicious with the throttle. And if you misjudge the speed, the adverse camber will push you off onto the grass. The concomitant loss of traction on such a steep incline can be disastrous. Moreover, if you enter the corner in too low a gear the engine may redline halfway up the incline, and conversely, in too high a gear the engine may bog down before you reach the top. In any event, you lose momentum at an inopportune time. Set the gear ratio so that you can traverse Ex-Mühle in one gear, without stressing the engine. Lastly, ill-tuned suspension may succumb to the abuse here, and leave the car unsettled at the exit. You will then need to delay getting back on power, until the car has settled sufficiently. In the image below, the car is at the 8 km mark, and is about to clip the apex as it climbs the steep hill of Ex-Mühle.

If you carried speed through Breidscheid and properly time your turn-in for Ex-Mühle, you may be able to sneak past an opponent or two at the apex of Ex-Mühle, as they stumble on the incline. Even if you cannot overtake them at the corner, you may well be able tuck in behind an opponent and draft past him on the following short straight. You will reach 4th gear along this straight. Swing to the right side of the track.

Lauda-Linksknick—While remaining in 4th gear at full throttle, neatly clip a late apex into Lauda-Linksknick, as shown in the image below. Remain on the left side of the track, thereafter. The apex speed of this left kink is frightfully high. This corner is named after Niki Lauda, an F1 triple champion, who nearly lost his life in a fiery crash at this corner, during the 1976 German Grand Prix. By the way, this storied Formula 1 season is the subject of director Ron Howard's 2013 film Rush.

Bergwerk (9 km)—Bergwerk has a few secrets. The inside line is very bumpy. The camber is adverse. The slope is still uphill, albeit a gradual one. And what appears to be the apex as you approach the corner is actually not; the real apex is hidden behind the hill on the right. But S2U provides a solution to the hidden apex problem—four helpful, black flags. The first three are shown in the image below. The second of these is opposite the false apex, and the third one is the true apex. So, slow down, follow the curve, and turn in late, as you reach the second flag.

It is vital that you get this corner right, because it is followed by a long, fast stretch. Begwerk is the northernmost point on the track, and the 9 km mark is at its exit. Accelerate and shift up to 4th gear.

Kesselchen (10 km)—Kesselchen is a long, uphill section that strings together four left kinks, three right kinks, and one more left kink. Most of the apexes in this section are hidden. Remain in 4th gear throughout this section. Pour on the coal now.

Initiate turn in for Kesselchen 1 as you approach the 10 km sign posted behind the Armco on the right, as shown in the image below. You will not be able to see the left apex until you reach that clump of people loitering behind the Armco at the base of the hill. Several of your computer-generated opponents will understeer off to the right onto the grass, here. Try to sneak inside them, as you hug the apexes of Kesselchen 1 and Kesselchen 2.

When you come out of Kesselchen 2, continue a gradual left turn, and begin creeping toward the right. At the apex of Kesselchen 3, try to be somewhere in the middle of the track, instead of attempting to clip the apex. As you approach Kesselchen 4, you should be on the right edge of the track, as shown in the image below. Note the blue overhead sign on the left side of the track. The second blue sign, which is hidden from view by the first, marks the hidden apex. Because you are travelling at a fairly high speed by now, you should initiate the turn-in earlier than your eyes tell you, in order to account for the power-on slide. Using the first blue overhead sign as the turn in reference works quite well, because it prompts you to turn in early.

Continue the climb in 4th gear. The next two corners, Kesselchen 5 and Kesselchen 6, are uneventful. Both are right flicks. Drift to the left side of the track after you pass the apex of Kesselchen 6. In the image below, you can see the right-hand apex of Kesselchen 7 marked by a black flag. Here, too, you will need to turn in early, in order to account for the power-on slide. Then, immediately flick left to clip Kesselchen 8's apex, and drift to the right edge of the track, as you reach the end of this long section.

Mutkurve (11 km)—Staying in 4th gear, left-foot brake just a touch to turn into Mutkurve, which is a deceptively fast left-hander. With an appropriate mix of courage, timing, and reflexes, this corner may be taken in 4th gear at full throttle. And if you set-up is right, you may even forego the left-foot braking at the entry. The stock E30 M3's suspension can take this punishment. Of course, if you take this corner at full throttle, you will have to turn in earlier, manhandle the car, and counter steer mid corner to avoid oversteer. In other words, four-wheel drift through the apex. At the exit, there is a low kerb on the right, flanked by a pair of black flags. You can venture over onto this kerb, if necessary. This is the 11 km mark. In the image below, the car is about to turn sharply into Mutkurve. Remember, do not slow down.

A number of your opponents will stumble here. Crush them. If you botched Mutkurve, you may well have to heel-and-toe down shift into 3rd gear, as you climb up the hill at the exit. Let us say that this is not ideal.

Klostertal—Approach Klostertal from the far left. This is a very fast right-flick, so take it in 4th gear at full throttle. You will not be able to see the apex, until after you have passed the low rise at the entry. Turn in early to account for the excess speed, and insert the car onto the inside of the crown. In the image below, the car is about to crest the little rise at the entry of Klostertal. The apex is still hidden behind the Armco, from this viewpoint. Stay to the right side of the track after exiting.

Steilstrecke—As you climb up the hill toward Steilstrecke, you will see the blue overhead sign marks the left flick at the entry. Before you reach the blue sign, heel-and-toe down to 2nd gear, just about where the car is in the image below. This is a wide, U-shaped turn with an increasing radius. You can four-wheel drift through it in relative comfort. Because it is a gradual corner, it does not qualify as a hairpin. Accelerate early and hard, shift up to 3rd gear, and gently clip the left apex at the exit, as you shoot out of the corner and climb up the hill. Go over to the right side of the track.

Caracciola Karussell (12 km)—To many, the name “Nordschleife” evokes the vision of this iconic corner, with its oddly banked, lumpy surface. It is named after Rudolf Caracciola, a great, 1930s German racer, who pioneered the use of the steep concrete banking, shown in the image below. The concrete banking was originally constructed to help drain rainwater off the track. But thanks to Caracciola, the conventional line now is to plant the car on the banking, thus extracting a bit of extra speed through this otherwise slow corner. And although this corner has a U-shape layout, its curvature is gradual and its banking is overt. So, this corner is not a hairpin turn.

Heel-and-toe down to 2nd gear at the entry of Karussell, and gently place the car onto the banking. Use care; the flat-to-banked transition is rather abrupt, so it can unsettle the car. If the car is still unsettled when you arrived on the banking, you may slide off the banking onto the flat part.

And maintain neutral throttle, while on the banking. If you are heavy-footed with the throttle, you will exceed the tyres' traction limit and slide off the banking onto the flat part. You will then lose what little speed you have. Use a touch of left-foot braking, if you find yourself beginning to slide off the banking. No matter what, do not mount the tall inside kerb, or you will get launched.

As always, do not look at the banking in front of your nose; look as far down the track as you can. When the exit becomes visible through the left window, as can be seen in the image below, begin accelerating smoothly. Time the acceleration so that you are at full throttle in 2nd gear as you cross the banked-to-flat transition, with your nose pointed at the Armco on the right. Again, take care not to upset the car too much at the transition. You are now at the 12 km mark.

You will find that a number of computer-generated opponents dive into this corner at an excessive speed, slide off the banking, bounce off the Armco on the outside, and continue on their merry way, without losing a beat. This is indeed a conundrum. It is likely a bug in S2U's artificial intelligence (AI) algorithm that controls the computer-generated opponents. Another gripe I have against S2U's reproduction of Caracciola Karussell is the smoothness of the banked surface. In real life, this banking is constructed of massive concrete slabs, so it is exceedingly lumpy. But S2U models the banking as a glass-smooth surface.

Note that some aggressive opponents may try to insert themselves underneath you, as you drop into the banking. They can shove you out of the banking and up onto the flat shoulder. So, protect the inside line by hugging the kerb.

Immediately after you popped out of the banking, you will see a pair of right flicks, in quick succession. Clip both the apexes, and accelerate onto a short straight that follows.

nürburg sector

Nürburg sector starts at the exit of Caracciola Karussell, and ends in the middle of the Döttinger Höhe straight.

Hohe Acht—Between Caracciola Karussell and Hohe Acht, there is a kilometre-long, unnamed stretch of track that includes a few interesting corners. I shall describe this bit as part of Hohe Acht.

You will shift up into 4th gear, while traverse the short straight that follows Karussell. At the end of this short straight, there is a fast, rising right-left flick, which we will call Hohe Acht 1. Take this corner in 4th gear at full throttle. Briskly flick the steering wheel to the left just before you reach the left apex. The sudden load transfer jacks up the left side of the car, so you may safely mount the apex of the left flick, without upsetting the car too much. In the image below, the car has just mounted the left apex of Hohe Acht 1. Another short straight that follows can be seen ahead.

Let the car drift over to the right side of the track on this second short straight. Heel-and toe down to 3rd gear as you approach the left-right combination that makes up Hohe Acht 2. You may straight-line this blind, uphill combination, if you time your turn-in right. In the image below, you can see the left and the right apexes perfectly lined up. Clip both the apexes neatly, and climb up the hill. Note that if you delay the turn-in until you see the alignment of the two apexes, you will be too late.

Both the apexes have large bumps that unsettle the car, so mind the entry speed. At least one computer-generated opponent will overcook the left flick and slide onto the marbles that guard the bit of track between the left and the right flicks of Hohe Acht 2. This is a bad place for him to make a mistake, because it is both slippery and bumpy. Time your entry, sneak inside him to clip the right apex, and leave him in the lurch.

Immediately beyond the hill of Hohe Acht 2, there lies a tricky right-hander, which is the actual Hohe Acht corner, but we will refer to it as Hohe Acht 3 in keeping with our unofficial numbering scheme. You will not be able to see the apex when you approach this bend, because it is hidden behind the Armco. And the track is adversely cambered at the apex. Also, there are marbles off the line.

If you carried speed up the rise at Hohe Acht 2, you can remain in 3rd gear through Hohe Acht 3. Otherwise, you may need to heel-and-toe down to 2nd gear, in order to avoid bogging down the engine. Turn in early, here. If your car understeers, you may wish to nudge the right front wheel against the kerb to rotate the car. In the image below, the car is about to clip the right-hander at Hohe Acht 3.

Hedwigshöhe (13 km)—Continue climbing the hill after you exit Hohe Acht. At the crest of this hill is a barely perceptible left kink called Hedwigshöhe. It is named after the track designer Dr. Otto Creutz's wife, Hedwig.

At the elevation of 625 m above sea level, it is the highest point on The Ring. It is 293 m above Breidscheid, the track's lowest point. In the image below, you can see the left kink of Hedwigshöhe. Clip the apex. Slip up to 4th gear as you crest the low rise at the apex. You are now at the 13 km mark, and are staring your descent back to the lowlands.

Wippermann—The next right-hander begins a fast but twisty and bumpy section called Wippermann. A right, a left, and another right closely follow one another. From the left edge of the track, turn in with gusto to clip Wippermann 1's apex. Remain in 4th gear. Use the inside of the crown. If you do not manhandle the car, the downhill slope and the fast speed conspire to produce a frightful understeer. The image below shows the downhill entry into Wippermann 1.

Some opponents may stumble at Wippermann 1, and subsequently have a high-speed crash. Be on the lookout to avoid these surprise chicanes. In the image below, the blue car crashed heavily and is partially blocking the track between Wippermann 1 (right) and Wippermann 2 (left).

Wippermann 2 is a treacherous little left-hander with an adverse camber. Heel-and-toe down to 3rd gear, take a late apex, and stay on the left side of the track thereafter. You are sacrificing the corner to ready for the next, but just as well, since the adverse camber here is going to slow you down, anyway. The line through this corner can be seen as a dark streak in the image below.

Stay in 3rd gear. Use a dab of left-foot brake to turn into Wippermann 3, a right-hander. Like Wippermann 2, this one, too, is adversely cambered. If your car understeers badly here, you may need to nudge the right front wheel against the tall kerb on the right for assistance with rotation. Plunge down the hill that comes after the apex, and glide over to the left edge. This downhill is quite steep, as can be seen in the image below. So, the more speed you carry through Wippermann 3, the better.

Eschbach (14 km)—Eschbach consists of a right and a left, both on downslopes and with adverse cambers. Eschbach 1's right apex is at the crest of a sharp rise. The understeer here is rather pronounced.

Remaining in 3rd gear, turn in early and give a little more throttle about halfway up the incline. This will loosen the rear wheels slightly, thereby mitigating the understeer brought on by the adverse camber. At the exit, the track drops away steeply. Rein in the car and drag it back to the right side, in preparation for the next corner.

Eschbach 2 is an increasing radius, double-apex left-hander. Take it while remaining in 3rd gear. Clip the apex of Eschbach 2A using the line highlighted by the dark streak in the image below.

Then immediately, clip Eschbach 2B's apex, as shown in the image below, and remain on the left side of the track. You may mount the low kerb at the apex without suffering ill effects. The 14 km mark is at the apex of Eschbach 2B.

Brünnchen—Brünnchen is a pair of tricky right-handers, both of which may be traversed in 3rd gear, if sufficient speed is carried through them. Brünnchen 1 is a particularly illusive corner. If you do not hug close to the apex, the car will experience a massive understeer, and will slide onto the left-side low kerb that runs the length of the downhill, short straight that connects the two Brünnchen corners. Going too far onto this kerb will drain speed. With a little excess speed through Brünnchen 1, you might even slide off onto the grass. So, left-foot brake, take an early apex, and stay close to the apex as long as necessary to prevent an off-track frolic.

Brünnchen 2 is the easternmost point on the track. The way S2U models it, Brünnchen 2 appears quite similar to Eschbach 1, both the entry and the exit. But in truth, Brünnchen 2 is slightly sharper than Eschbach 1. So, gently dab the brake pedal with your left foot at the turn-in to slow the car to an appropriate speed and to help rotate it into the corner. But if you slow down too much, you may be obliged to heel-and-toe down to 2nd gear, in order to claw your way up the steep incline. More importantly, do not mistake one corner for the other. If you were momentarily inattentive and mistook one corner for the other, you will lose your location awareness and confusion will follow, directly.

Eiskurve—Eiskurve is so named because in winter it is usually covered in thin, black ice, due to it being perpetually shaded by tall trees, as can be seen in the image below. Approach Eiskurve from the right side of the track, turn in late and hard, and place the car on the inside of the crown. If timed right, this corner may be taken in 3rd gear. If you made a cock-up of the entry, you may need to heel-and-toe down to 2nd gear to climb out of Eiskurve.

Although the bit between Wippermann and Eiskurve is undulating, twisty, slippery, and bumpy, it is certainly possible to traverse the entire stretch in 3rd gear. To accomplish this, you must know the proper lines through all these twists and turns, remember where the bumpy and slippery spots are, and carry speed through them by constantly dancing on the throttle and brake pedals.

Pflanzgarten (15 km, 16 km)—Pflanzgarten is a rather long section that includes two steep, high-speed drops where you can get airborne, if driven exuberantly. Both drops lead into sharp right-handers. So, it is possible for the unwary to confuse these two drops. Be forewarned.

Accelerate out of Eiskurve and shift up to 4th gear when you reach the top of the crest at the exit. The approach into the first drop at Pflanzgarten 1 is long and sinuous, but not complicated. While remaining in 4th gear, settle the car on the left edge of the track, and plunge down the drop. In the image below, the car is approaching the ledge. You are now at the 15 km mark.

Once the car reaches the base of the drop at Pflanzgarten 1, heel-and-toe down to 3rd gear, settle the car as quickly as possible, and turn in briskly for the double-apex right-hander that follows. If necessary, use left-foot braking or steering rocking to prevent understeering off onto the gravel trap. In the image below, the first orange overhead banner marks the apex of the first right-hander, and the third banner marks the apex of the second right-hander. The devious gravel trap is nestled between the red-and-white crash barrier and the left edge of the track.

After coming out of Pflanzgarten 1, shift up to 4th gear while on the bendy approach into Pflanzgarten 2, where another drop awaits. Float over to the left edge of the track, settle the car with a dab of left-foot braking, and take the plunge. As can be seen in the image below, this drop is even steeper than the one at Pflanzgarten 1. You must slow down at the approach and place the car precisely onto the narrow racing line next to the left apex. Otherwise, you may understeer toward the middle of the track, and will be lobbed high in the air by the big ledge that looms over the drop. You will then lose a lot of time trying to wrestle a mad, bucking bronco. This is bad, because a long, fast stretch is just ahead.

Coming out of Pflanzgarten 2, you will come upon a stretch that includes two pairs of right-left kinks. This is Pflanzgarten 3. You will reach full throttle in 4th gear at the end of this section. It is long, fast, twisty, bumpy, and slippery, so it can be a challenge to keep the car on the track. But it is also a section in which you can gain time over your faltering opponents. The apex kerbs are high; do not mount them, especially at this high speed. Pflanzgarten 3 is rhythmic; it demands a keen sense of timing and a deft touch. The 16 km marker is located between the first and the second pair of right-left kinks, about where the car is in the image below. Along with Hatzenbach, I rather fancy Pflanzgarten, because it too is long, technical, and fun. Remain on the left side of the track at the end of Pflanzgarten.

Schwalbenschwanz—Schwalbenschwanz comprises of a right- and a left-hander. Approach Schwalbenschwanz 1 from the left side, while in 4th gear at full throttle. Heel-and-toe down to 3rd gear, after passing a pair of black overhead signs and just before the two blue overhead signs that mark the apex of the right-hander. Turn in sharply just as the left-hander at the top of the hill becomes visible. In the image below, the car is initiating the turn-in for Schwalbenschwanz 1, and Schwalbenschwanz 2 is barely visible. It is that curvy, uphill portion shown just beneath the rear view mirror. Hug the right apex kerb at Schwalbenschwanz 1, and remain on the right side of the track. Schwalbenschwanz 1 is faster than it appears. Carry a bit more speed through it than your instincts dictate.

While remaining in 3rd gear, make an early turn in for Schwalbenschwanz 2, whose apex is marked by a pair of black overhead signs. Do not understeer onto the right-side high kerb at the exit. Accelerate out of the exit and drift over to the right side of the track. Stay in 3rd gear.

Kleines Karussell (17 km)—This corner is called Kleines Karussell, the mini-carrousel, because it is shallower and shorter than Caracciola Karussell. Despite its shabby appearance, this corner is quite fast. While remaining in 3rd gear, left-foot brake into the corner and power through it, using the light-grey concrete banking for support. Stay on the banking; do not try to clip the apex. Be smooth over the surface transitions as usual, and do not slide out of the banking. Enter this corner as shown in the image below. The 17 km mark is at the end of the banking. Shift up to 4th gear as you accelerate out of Kleines Karussell, and remain on the left side of the track.

Galgenkopf—Galgenkopf is a long, double-apex right-hander, with the up-to-down slope inflection located at the midpoint between the two apexes. Stay in 4th gear, left-foot brake, and turn smartly into the first right-hander. Hug the apex, as shown in the image below. If necessary, nudge the right front wheel against the kerb to ameliorate understeer.

Drift over to the left edge at the top of the crest at the middle of the corner, and begin turning into the second right-hander. Get back on the throttle as soon as maybe, so as to take advantage of the long, long straight that follows.

Döttinger Höhe (18 km, 19 km)—Döttinger Höhe is not a corner. Indeed, it is one of the longest straights on any racing circuit. If we do not consider the fast kinks at Antoniusbuche and Tiergarten as corner, this section was even more awe-inspiring on the pre-1967 track, when there was no Hohenrain Schikane and the old pit straight extended the reach of Döttinger Höhe an extra kilometre, all the way down to the Südkehre. That was about 5 km in length.

In its present form, Döttinger Höhe starts at the Audi gantry that marks the exit of Galgenkopf, and ends at the Bilstein bridge just before Antoniusbuche. The Audi gantry also marks the 18 km point. The 19 km mark is where the Touristenfahrten car park is located off to the right side of the track. Remember, as I mentioned at the beginning of this chapter, the track entrance gate at the car park is actually the 0 km mark on the real track.

Beyond the Audi gantry, the track elevation drops noticeably, as can be seen in the image below. Shift up to 5th gear as you descend down the slope and stay on full throttle, until you pass the left-hander at the entry of Tiergarten. That means you take the left kink at Antoniusbuche, the one under the Bilstein bridge, at full throttle in top gear. The only concerns you have on this straight are to draft past an opponent and to avoid being passed. If you are to adhere to the rules of racing, you should not weave from side to side as an opponent comes up from behind. So, that makes drafting to overtake your only task, here.

That was a long, long lap, was not it? But wait, there is more. Another configuration of the Nürburgring, called the Veranstaltergemeinschaft Langstreckenpokal Nürburgring, is even longer than the Nordschleife. When I say longer, I am not referring to the name, but to the track length. Read on.

CHAPTER SIX — LEARNING THE GRAND-PRIX-STRECKE

overview

The Grand-Prix-Strecke, or the Formula 1 Grand Prix track, is the appendix that sprouts out of the Nordschleife at its southern end. It is 5.148 km long and has 16 corners. The track map is shown below. Some corners have names, others only numbers.

In a book about the Nordschleife, I included the F1 track, as a bonus. But this bonus comes with a compound interest. The Nürburgring 24-hour endurance race is run on the 25.947 km track that combines the Nordschleife and the F1 configurations. Knowing how to drive both the Nordschleife and the F1 track enables you to drive the 24h configuration, as well. The catch, though, is that S2U does not model the 24h configuration. But several other popular simulators, including rFactor and GT5, do. So, it is useful to know the 24h configuration.

I begin with the description of the F1 track. Then, I point out the corners that join the F1 track to the Nordschleife, thereby forming the longer, 24h configuration.

grand-prix-strecke

Start-und-Zielgerade—As you come out of the final corner onto the front straight, you pass under the BMW gantry. You will have taken the final corner in 2nd gear. Accelerate and go up through the gears. The starting line is under the gantry. The image below shows the car exiting the final corner. The gantry is visible ahead.

As you can see in the track map above, the so-called front straight is actually crooked. If you followed the left edge of the track, you will have to contend with the right kink, before you reach the first corner, thus disrupting your approach. Instead, do the following. As you come out of the final corner, point the car at the green light shining on the BMW gantry. In the image above, the green light is visible on the mid section of the gantry, between the two tall poles. Continue along this trajectory after you passed the starting line.

Yokohama Kurve—When you approach the first corner, Yokohama Kurve, you will already be in 4th gear. If you stayed on the straight-line trajectory mentioned above, you will clip the apex of the right kink, which is where the pit exit road joins the front straight. In the image below, the car is about to clip the apex of the right kink. The pit exit road is visible, to the right of the car.

Immediately after passing the pit exit road, brake hard, heel-and-toe step down to 2nd gear, and continue along the straight-line trajectory. This will place the car on the left edge of the track at the entry of Yokohama hairpin, as shown in the image below. The braking zone is bumpy and is on a downslope. So, modulate the brake pressure, in order to avoid locking up the wheels.

Now, turn in sharply while remaining in 2nd gear, clip the apex, and accelerate out of the hairpin. This corner is tight enough that you may have to shift the position of your left hand to the bottom of the steering wheel, before you initiate the turn. Refer to the pushing hand technique I mentioned, earlier. There is a large dip at the apex, which can unsettle stiffly sprung cars. But the stock E30 M3 can negotiate this corner without too much trouble.

Note that in a race, you may have to modify the straight-line trajectory I mentioned above, since there would be cars jockeying for position all around you. But once you have mastered this straight-line approach into Yokohama Kurve, you can readily adapt your line to suit the racing situations. Just remember to protect the inside line.

Corner 2—Coming out of the hairpin, the track rises slightly. Accelerate up the rise, and move the car to the right edge of the track. Remain in 2nd gear. The apex of the second corner is at the top of the rise, as shown in the image below. This corner is a lot tighter than it looks, so be patient—delay the turn-in, and delay the return to throttle.

When you come out of the second corner, point the car at the yellow tent, and move over to the right edge of the track. Below, the tent can be seen in the middle of the image, behind the distant retaining wall on the far side of the gravel trap. By now, you will be in 3rd gear.

Corner 3—The second corner is tight, but the third is tighter, because it blends in with the fourth. At the entry, about where the car is in the image below, heel-and-toe down shift into 2nd gear, and turn in hard. The yellow tent is now clearly visible, next to the rear view mirror, on the right side of the image.

Clip the left apex of the third corner, and point the car at the apex of the fourth corner, as shown in the image below.

Corner 4—There is hardly any gap between the previous corner and this one. So, treat the exit of the third corner as though it were the entry into this. While remaining in 2nd gear, mount the apex curve, as shown in the image below. Be sure to return to throttle as early as maybe.

Let the car drift onto the green-painted exit curve on the left side of the track, and accelerate hard out of the corner. Although the track map labels the right kink here as the fifth corner, it is hardly noticeable, so I shall skip it.

Corner 6—Go up through the gears along this short straight. By the time you passed under the gantry at the approach of this corner, you will be in 4th gear. When you reach the patch of tarmac on the right, as can be seen in the image below, heel-and-toe down shift into 3rd gear, and ease into the corner. Plant the car on the inside of the crown, and clip the left apex.

Corner 7—The seventh corner comes up, shortly. Heel-and-toe down shift into 2nd gear, and manhandle the car into the corner, as shown below. Get back on the throttle as early as you can, and roll down the hill. Do not mount the apex kerb; it is a bit too high. Execute this corner properly, for it leads onto a fast, downhill stretch.

Corner 8—The eighth corner is another hairpin, but it is a lot wider than the first one. You will be in 4th gear as you approach this corner. Begin decelerating when you reach the unpainted, grey kerb on the left, as can be seen in the image below. Heel-and-toe step down to 2nd gear, before you start the turn-in. A number of computer-generated opponents will stumble on the downhill braking zone. So, as you come out of the previous corner, pick a victim, draft behind him as you come down the chute, dart out at the last moment, and occupy the inside line. Be delicate with the brake; modulate.

Because the curvature of this corner is rather gradual, you can begin accelerating as soon as the car is pointing at the apex. Hug the apex kerb, as shown below, and continue increasing the throttle smoothly. Release the car onto the green-painted exit kerb, and shift up into 3rd gear.

Michael Schumacher S—Remain in 3rd gear as you go up the hill toward the S-bend, a fearsomely fast corner appropriately named after an equally fast seven-time F1 world champion, Michael Schumacher. While I write this in January 2014, Germany's favourite son remains in an induced coma, as a consequence of a serious head injury he sustained during a recent skiing accident.

Take this corner in 3rd gear at full throttle. Initiate turn-in, as soon as you passed the entry kerb on the right, which can be seen in the image below. Mount both the left and the right apex kerbs, as you climb through this corner. These kerbs are not so tall as to upset the car. If you are not smooth with the steering input, though, you may experience oversteer between the two apexes, where the rear end wants to come round to the right. Just catch it with the steering wheel; do not slow down.

Corner 11—After exiting Schumacher S, shift up to 4th gear and continue to climb the hill, and ease over to the right side. As you approach the red-painted tyres on the right side, as shown in the image below, heel-and-toe down into 2nd gear. This corner is very similar to the sixth corner, but it is somewhat tighter, hence slower.

Warsteiner Kurve—At the exit of the eleventh corner, the upslope of the track levels off. You will be back up in 3rd gear by now. Approach Warsteiner Kurve from the right. Then, at the right moment, flick the car to the left, and immediately flick back toward the inside of the corner. Now, four-wheel drift through the apex. Using the Scandinavian flick here like this allows you to carry more speed through this otherwise slow corner. Retain as much speed as you can through this corner, since a very fast and long straight is next, as can be seen in the image below. After exiting, shift up to 4th gear. Warsteiner Kurve is a wider, faster version of the seventh corner.

ADVAN Bogen—The ADVAN Bogen is fast, very fast. In fact, it is so fast that it is hardly a corner, at all. So, take it in 4th gear at full throttle. Initiate turn-in, when you reach the yellow crane parked off to the left behind the Armco, as shown in the image below.

NGK Schikane—Continue up the hill in 4th gear at full throttle. Just after you passed the white, 100 m board (the second of three such boards) on the right, as shown below, decelerate and heel-and-toe down shift into 3rd gear.

After passing the 50 m board (the final board), heel-and-toe down shift into 2nd gear, and initiate turn-in. You can skip over the low apex kerbs, and straighten out this chicane, as shown in the image below. You can even get on the green, rough patch behind the right-apex kerb, provided you do not let all four wheels leave the track surface.

Corner 16—Out of the chicane, accelerate, shift up to 3rd gear, and continue climbing uphill. Just before reaching the four cones blocking the exit road on the left, as can be seen in the image below, heel-and-toe down shift into 2nd gear. And when you reach those cones, turn in, hard.

As soon as the car is pointed toward the apex, return to throttle, hug the kerb on the right, as shown below, and zoom onto the front straight. This final corner is similar to the eighth corner, except that it is wider and faster.

That was a lap around the Grand-Prix-Strecke. Now, let us talk about how we can connect the F1 track to the Nordschleife, so that we may drive the 24h configuration. You would, of course, need a simulator that models the 24h.

gesamtstrecke

24h Yokohama Kurve—The 24-hour endurance race starts at Start und Zielgerade, as well. But when you reach Yokohama Kurve hairpin, you make a 90-degree turn, instead of the usual 180-degree turn, and point the car at the side road blocked by the five cones, shown in the image below. When the track is configured for a 24h race, this side road will be open, but the main track going off to the right will be blocked.

After you make a left turn onto this side road, you will re-join the main track at the fifth corner. Refer to the track map shown at the beginning of this chapter. So, the 24h configuration shunts the second through the fourth corners of the F1 track.

24h NGK Schikane—Another 24h modification is at the NGK Schikane. The 24h configuration bypasses the usual, tighter line using a more gradual side road, which is shown blocked by the red-and-white crash barrier ahead, in the image below. When the track is in the 24h configuration, this side road will be open, but the chicane on the left will be blocked.

24h Corner 16—When you re-join the main track beyond the NGK Schikane, you will make an immediate left turn onto the exit road that leads onto the Nordschleife. In the image below, the side road is shown blocked with four cones. The blue wall seen just ahead is the very same one that lines the Start-Ziel short straight of the Nordschleife. The usual right turn that continues onto the front straight will be blocked in the 24h configuration.

24h T13—When you complete a lap of the Nordschleife and enter into T13, instead of turning right onto the Start-Ziel short straight, go directly under the steel gantry, as can be seen in the image below. In the 24h configuration, the exit road will not be blocked with a red-and-white crash barrier, but T13 right turn will be blocked. You are now back on the front straight of the F1 track, thus completing one lap of the 24h configuration.

The 24h configuration is 5.115 km longer than the Nordschleife. And as if that is not hard enough, the real-life drivers race through the night for a full 24 hours. Yes, driving the Nordschleife at night, plus the F1 track, plus sleeplessness to boot. The 24h race is very tough, indeed.

CHAPTER SEVEN — CONCLUSION

postscript

I see that you are still awake. That you have endured through these long, dense passages is sufficient evidence that you are dedicated to the craft. Keep accumulating seat time, and you will surely master race driving and will learn to enjoy the Nordschleife and other famous racetracks.

By seat time, I mean putting in a few laps, striving to improve your time, and then evaluating your performance using the replay video and the telemetry. All drivers, even the professionals, make mistakes every now and then. So, do not be disheartened. Just as there is no such thing as a perfect set-up, there is no such thing as a perfect lap. The key is to avoid making major mistakes and to learn to recover from the inevitable, minor ones, and of course not repeating the same mistakes.

Starting when he was six, I encouraged my son, Ronan, to drive on The Ring a couple of times a week, one lap per session and only if he expresses a desire to drive. In those days, he needed a couple of pillows behind his back, so that he could reach the G25 pedals mounted on the Playseat. Initially, I sat next to him, and narrated the corner names and pointed out the lines through them, each time he drove the track. After a few weeks of this informal, low-intensity coaching, he was able to put in a lap without crashing, albeit not on the optimal lines through all corners. And he soon developed the ability to recognise the key corners by sight. More importantly, he could recall several corners in a sequence, without my prompting. The recognition and recall abilities are indispensible for racing on any track, and especially so on The Ring. These skills take time to develop, and they are perishable. In the early days, my son discovered to his dismay that after a fortnight's holiday away, he had forgotten some of the corner names. No worries though, for the erstwhile memories soon return after a quick refresher. So, patiently develop the memory, and maintain it through regular use.

Learning the Nordschleife is like washing a pile of dirty plates. The dirty pile looks daunting before you begin. But focus on washing one plate at a time, and soon you have a pile of clean plates. Work through the corners and sectors in the same way: one at a time.

First, focus on stringing together a few laps on the Nordschleife in a stock E30 M3 in about eight minutes and change, without making a major mistake such as sliding off the black stuff, fishtailing the car, or worse, crashing into a barrier. If you are driving a DTM-upgraded M3, aim for seven-plus-minute laps.

If you get to the point where your lap times are consistently within a second of each other, you have learnt the track sufficiently well. Now, redirect your attention to reducing the lap times by shaving milliseconds, here and there. To get a sense of your progress, compare your lap time against the real life records set on The Ring. If you can beat the real life records in a similar car, do try to suppress the smirk. In setting the times on the real track, these chaps risked their lives and limbs; we simulator drivers face no risk whatever. Consequently, we can be a lot braver than they.

When your lap times have settled and are within a striking distance of real life records, it is time to start developing race craft by pitting yourself against the computer-generated opponents. Initially, practise stalking them, and learn to identify visually their weak points. Once you are able to read them, overtake them where they are at their weakest. Avoid locking horns at places where they are strong. Practise patient, pull back, and watch them stumble, then go around them. In real life, it is possible to vex the driver ahead by hounding him, lap after lap, thus inducing him to make mistakes. That tactic does not work on S2U's computer-generated opponents. But they will surely pull that trick on you, if you fail to check your nerves.

Next, expand your skills by learning other famous tracks in S2U, like Spa, Bathurst, Suzuka, Dijon, Rouen, Laguna Seca, Zolda, Brands Hatch, Donington, Catalunya, Hockenheimring, Monza, and Silverstone. I listed these tracks here in the descending order of my preference, but they are all superb racetracks.

When you can beat your computer-generated opponents consistently on all these tracks, prowl round on-line, and race against human opponents. In general, Group D races will offer better opportunities to learn and improve your craft. Rammers and slammers shun these slow races. Hence, you have a better chance of finding like-minded racers there. When you are in a race against serious drivers, be fair and avoid the conducts that would be deemed unsportsmanlike or illegal on real life racetracks.

Here are my last few bits of advice. Calm your nerves. Practise patience. Never give up. Always learn from each lap.

Good luck.

resources

Physics

- *Physics I: Classical Mechanics*, MIT Open Courseware
- *Physics II: Electricity and Magnetism*, MIT Open Courseware
- *Physics III: Vibrations and Waves*, MIT Open Courseware
- *The Feynman Lectures on Physics*, Feynman

Engineering

- *Engineering Mathematics*, Stroud
- *Advanced Engineering Mathematics*, Kreyszig
- *Chassis Engineering: Chassis Design, Building & Tuning for High Performance Handling*, Adams
- *Engineer to Win*, Smith

Motorsport

- *The Technique of Motor Racing*, Taruffi
- *Ayrton Senna's Principles of Race Driving*, Senna
- *Drive to Win: The Essential Guide to Race Driving*, Smith
- *Tune to Win: The Art and Science of Race Car Development and Tuning*, Smith

ENDNOTES

Notes

1. The BMW E30 M3 model for Google SketchUp 3D was made by Mirza.
2. The original diagrams were downloaded from Dr. Gustave Stroes's E30 M3 Performance web site http://www.e30m3project.com/e30m3performance/.
3. The original colour photograph of this BMW E30 powertrain was downloaded from Robert Feagans's Everything Mechanical Engineering blog at http://rcfeagans.blogspot.com/p/bio.html.
4. See *Handbook of Driving Simulator*, § 14.2 *Theories of Simulator Sickness*.
5. This photograph of the Piloti Spyder S1 racing shoe was downloaded from http://piloti.com/product/spyder-s1/.