HIGH PERFORMANCE DRIVER EDUCATION

HPDE HANDBOOK

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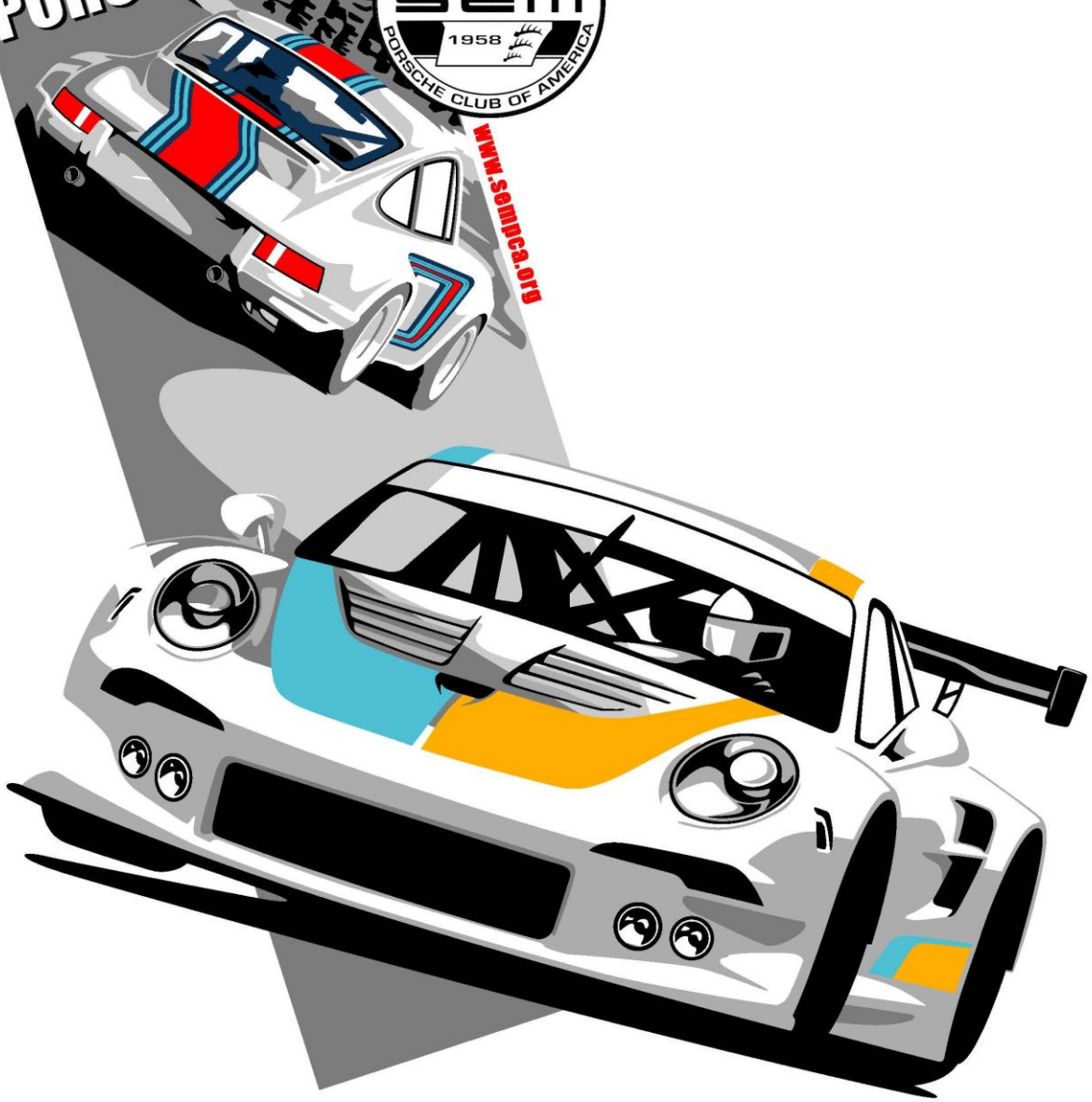

Introduction – This handbook is a selection of fundamentals put together to help you increase your knowledge of both car dynamics and driving at Higher Performance levels. It begins with the concept of understanding the complete driving 'System'. A system that encompasses 5 varying elements that must all be considered and are key in further developing your skills. Included after that are detailed outlines of some of the principles, techniques, and terms that will guide you as you progress. This book is meant strictly as an aid and is in no-way a replacement for actual practice and experience. The information contained here-in should serve as a basis from which you can expand upon by attending several of our Driver's Education events.

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Start with Driving Style: A System of 5 Elements

1: The first element - The human being:

Why you first? Because you are the driver. Because in the end, everything depends on yourself. You want to become a better driver, you want to be faster, you want to be in control of the car, you want to learn (which means to accept criticism and feedback, discipline and endurance) — you want to win! You are the most variable Element of the whole System.

Start with an honest assessment of your mood and condition for the day ("I've had better days" — then be careful!!). Do you like the weather conditions (rain, cold, humid, …) please adjust accordingly. What's your personal condition today, are you aggressive today (good and bad), are you tired etc.? You have the ultimate responsibility about what you do — nobody else is to blame!! No counterpoints, No excuses.

Ultimitaly you are responsible and high performance driving / racing is dangerous by nature! Good drivers know themselves truthfully. Their strengths and weaknesses and work within them. Be Aware !!

2: The second element - The course, the race track:

The one who gets on the throttle first usually wins. The goal on every track, every corner is to exit the turn as fast as possible. Notice this is exit the turn. This is only possible with the "perfect line"! Anyone can go fast on a straight. Poistioning the car going onto a straight is the key.

Sterling Moss - *"It is better to go into a corner slow and come out fast, than go in fast and come out dead."*

In order of priorities it's always turns first, then straight aways. Why? Because in a turn we have a choice how to drive it and how to adjust the speed. A straight section on the course remains a straight section. Turns can be "progressive" (radius gets tighter) or degressive (radius gets wider), they can go uphill or downhill and can have different surfaces. The key: Everything has to be analyzed and driven accordingly. We'd like to do that and to know everything about it, because we'd like to be a better driver than average. A combination of turns should always be understood backwards, the last needs to be analyzed first in order to figure out the fastest time (with exceptions). The last turn impacts how you enter a straight so that one holds the highest priority. You may have to sacrice speed in the early part of a combination to maximize the exit.

So what's the perfect line? In theory and geometrically it's the max radius that suits the shape of the turn. Think of it as the 'straightest way through a corner' utilizing the track width. Cars are fastest in a straight line so you are looking to open the corner up as much as possible. Or sometimes it's the line that we choose for a specific car set-up that may require deviation from theory slightly to obtain the fastest time. You will need to analyze each corner keeping this theory and your entire System in mind.

Walter Roehrl - *"Only one adjustment at the steering wheel for one turn" (except entering and exiting).*

Jackie Stewart - *"The driver should never feel the end of the turn, the transition from lateral acceleration to longitudinal acceleration should be as smooth as possible."*

3: The third element — Conditions and circumstances:

The weather, fluids on the track, dirt, animals, new pavements, temperature of the surface. These all need to be considered and are ever-changing. The key: Don't complain, try to work with all those conditions and not fight them. Understanding them and their effects is part of the process to become a good driver. Learn to be capable of adjusting accordingly and still be as fast as possible or to drive the car at those (new) limits. Everything abnormal requires changes to yourself, the line, the car, the dynamics etc.

4: The fourth element - Your car:

Different cars, set ups and configurations require somewhat different driving techniques. You will need to become familiar with the specific car dynamics of the car you are driving. Things such as it's tendency to understeer or oversteer, is it front/rear or all wheel drive, where is the location of the center of gravity, what aid systems is it equipped with (ESP, PSM, ABS) and how do they affect the car. Understanding these and the cars strengths and weaknesses are important factors. Basic rule: Never try to drive a car against its character! Try to bond yourself to this character and work with it.

5: The fifth element — SGBCG: Steering, Gas pedal (Throttle), Brakes, Clutch, Gear shifting:

- **Steering**: You steer with your eyes, you do everything that your eyes do, steering is just a reaction of what the eyes in combination with the brain do. Regarding turns that means: Look ahead, always' Once the turn is completed, the eyes focus on the next turn already. Always smooth inputs, no jerking on the wheel! The goal is only one steering input for every turn (this is the requirement for a smooth style). Position hands at the steering wheel at 9-3 (10-2). They should not cross 12 o'clock during a turn (that may require changing position of hands just before a turn. Always steer with "push", the other hand does not pull, the other hands just slightly supports the motion (for a right turn: left hand pushes, right hand slightly supports by pulling but has no majority).
- **Gas / Throttle**: reacts as accelerator or brake — dynamic behavior of the car changes accordingly — e.g. getting off the throttle in a turn can be dangerous, because you "brake" only the rear axle (not the front, except awd). You can also "steer" with the throttle, e.g. trailbraking in a turn to get the right / better angle for the exit of the turn and to be faster on the throttle again. Small adjustments should be the focus.
- **Brake**: Shortly before ABS 'threshold' is the maximum braking point. Braking should be done in one short, purposeful burst. This will insure full use of both the braking system and the contact patch. Another technique to consider is "left foot braking". In some instances, this may allow the transition of braking to acceleration to be smoother. The effect of this is the non-driven axle (front in rear drive cases) receives load, which can be beneficial for car dynamics in turns.
- **Clutch**: Operate of the clutch must be completed before reaching a turn, otherwise dynamic car behavior changes drastically! Use "heel and toe technique" or "tilting foot technique" to create a smooth transition while changing gears and braking at the same time.
- **Gear shifting**: Avoid shifting gears in turns. This will cause a load change in the vehicle. Avoid shifting between 2 quick turns. Try to figure out the "dead point"where you are not turnning and the car dynamics are neutral.

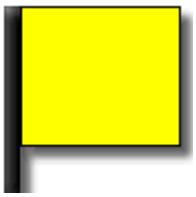
Driving 'at the limit' is:

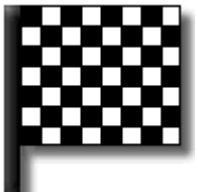
1. As close as possible to maximum grip
2. Minimum time in braking zone
3. Minimum time in "changing zone" (transition braking to accelerating)
4. Maximum utilization of track width
5. Smooth load changes
6. Leave partial load zone as soon as possible (zone w/o full throttle)
7. As much speed as possible at turn exit
8. Most possible utilization of "full throttle zone"

Mental Training - "Driver's Prayer":

1. Everything that disturbs or distracts me is outside the car
2. I sit in my car — everything is adjusted to the right position
3. I relax
4. I accept the responsibility about myself and of the car
5. I am awake and concentrated
6. The only thing I am thinking about is the driving - nothing else
7. Now I can start

FLAGS

Flag	Colors	Description
	Green Flag	Track is Open and Clear
	Yellow Flag	**Stationary**: Caution - Track is not clear, but there is no immediate danger to you. Slowdown. **Waved**: Immediate Caution - Track is not clear ahead. Slow down and be prepared to take evasive action.
	Red Flag	Stop quickly and Safely to one side of the track. Stay in your car. Do not proceed until advised by flag crew.
	Black Flag	Pull into pits immediately. There is something wrong with your car, your driving, or you.
	Blue with Yellow Strip Flag	Passing flag. A faster car is attempting to pass you. Give him/her room.

	Red & Yellow Flag	Flag indicating track surface change / slippery track conditions.
	White Flag	Caution: Emergency vehicle on track.
	Checkered Flag	Run is over. Pull into the paddock.

PROPER SEAT POSITIONING

The buttocks should be tucked firmly against the lower back of your seat, with your back erect and against the seat. This seating position will keep you alert and the total contact of your body with your seat will feed back valuable information to you about the road conditions your car's suspension and tires.

The distance between your steering wheel and seat should allow your arms to be comfortably bent when you hold the steering wheel. This will allow you to react quickly with full use of your arms in case of emergency evasive maneuvers, and will also be less tiring on your arms. Your arms should be slightly bent at the elbow your hands located in the 3 and 9 'o clock position on the wheel with thumbs resting on top of the spokes. Holding your steering wheel in this fashion will allow you to sense first-hand information fed to you through your steering column into the wheel. You will also find that you have more strength available while maneuvering your car. Your arms will get less tired - and in case of emergency evasive maneuvers, you will have all that extra strength to help you. Let both hands do the work! While one pulls, the other can push the wheel smoothly! **Note: never to cross your arms while steering around sharper turns.** Preset hands to a new position briefly if needed for a sharper corner, then promptly return them to the 3/9 postion.

Picking up vibrations from the brake, clutch and throttle pedals are also very important. Use the ball of your foot on the brake pedal, with your heel off the floor so you can feel the pressure you apply. This allows you to feel when the brakes are beginning to lock up the wheels. Legs should be slightly bent when fully extended to the pedals so you don't have to stretch the legs and feet.

Your lap and shoulder belts should be fairly tight with just enough room to allow you to reach the dashboard controls. Seatbelts are important for several reasons. They will hold you in place and keep your body tucked into your seat for maximum feel and feedback. In case of emergency evasive maneuvers, they keep you in place behind your steering wheel, instead of having you slide around the front seat. They will keep you from hitting the steering wheel.

SMOOTHNESS AND CONSISTENCY AND CONCENTRATION

Smoothness is very important. Any sudden input of brake, throttle, clutch or steering will cause sudden weight transfer in your vehicle and lessen your car control. It may also start a skid or accident!

“Less is more" !
“I am slow" is actually faster once you become smooth regarding all inputs:

1. Steering input
2. Throttle input
3. Brake input

“The Dance" — smooth driving is like a nice dance: Everything fits, everything flows, everything engages smoothly into each other. All famous excellent race car drivers are smooth, proved to be very consistent and have a highly sophisticated ability to concentrate over a long period of time (one record fast lap time doesn't make a winner.)

UPSHIFTING AND DOWNSHIFTING

1. Shifting:
Cup your hand on top of the knob and gently guide it into first gear with the heel of your hand. Now, use your fingers to move it into second gear and then into third gear. Now, gently ease it into fourth gear. Treat the gear shift lever knob gently as if it were fragile, like an eggshell. Don't grab or yank it into gear. You may get into the wrong gear or destroy your transmission. Most transmissions shift smoothly if you just guide the shift lever into the proper gear in a smooth manner.
2. Heel and Toe Downshifting (see “terms” for visual on page 15):
This is the technique of operating the brake and gas pedal simultaneously with the right foot while clutching with the left foot. If your car has an automatic transmission, this does not apply to your kind of driving. Heel and toe downshifting allows you to brake and match the engine rpms to the lower gear at the same time, which allows for smooth downshifting.

Here is how it is done:
First you start to squeeze on the brake pressure to slow down the car. Then pivot the heel or side of your right foot over the throttle, maintaining even brake pressure. Depress the clutch with your left foot, moving the shift lever into neutral on your way to the next gear. On releasing the clutch halfway, squeeze the throttle on to bring up the engine’s rpms. Depress clutch- again, quickly, and shift into the lower gear. Release the clutch smoothly, then pivot your right heel off the throttle back to below brake pedal and complete braking. This technique is called heel and toe downshifting with double clutching.

UNDERSTEER AND OVERSTEER

Understeer — A front wheel skid.
Cause: Too much speed in a corner in an inherently understeering car (front engine).

Correction: Ease off throttle half a throttle setting to transfer weight to the front wheels; add steering to get proper line back. If need be, back off the throttle all the way and again add the steering correction. Too much braking which causes front wheels to lock. Ease off brakes smoothly or reduce brake to get front wheels unlocked (or rolling), add steering to get proper line back.

Cause: Violently spinning front Wheels (front wheel drive car).

Correction: Ease off throttle to stop front wheels from spinning and to transfer weight to front tires, add steering to get proper line back. Then apply throttle progressively and adjusting as necessary.

Oversteer - A rear wheel skid or slide.
Cause: Too much speed in a corner in an inherently oversteering car (rear engine). Rear end slides out.

Correction: First add steering quickly into direction the rear end is sliding (counter-steer).
On dry pavement, add some throttle to transfer weight to the rear wheels. When rear end starts coming back, correct steering quickly into opposite direction to counteract second skid. As car comes out of second skid, bring wheel smoothly back to straight and continue on proper line.

Cause: Braking too hard causing the weight to transfer abruptly for which causes the rear wheels to lock.

Correction: Come off brakes quickly and add steering as rapidly as possible
into the direction the rear end is sliding. When rear end starts coming back, correct steering quickly again to gain back proper line. Then add smooth throttle to help move the car in a forward direction.

Cause: Violently spinning rear wheels (rear Wheel drive car).

Correction: Ease off throttle to stop rear wheels from spinning and quickly
add steering in the direction the rear end is sliding. When rear end starts coming back, quickly add steering again to gain back proper line. Then smoothly squeeze on throttle to keep the car moving in a forward direction.

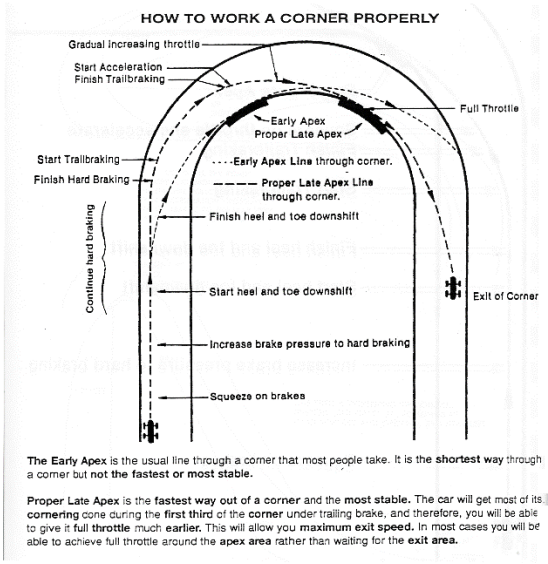
TRAIL BRAKING TECHNIQUE

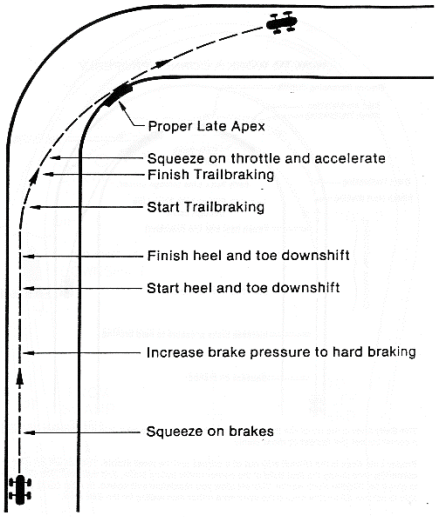
This is a technique using the brakes as a handling device as well as a braking device.

As you approach a turn, initiate your braking smoothly to transfer the weight forward, setting the chassis by compressing the shocks and springs. Thus, increasing the front tire patches.

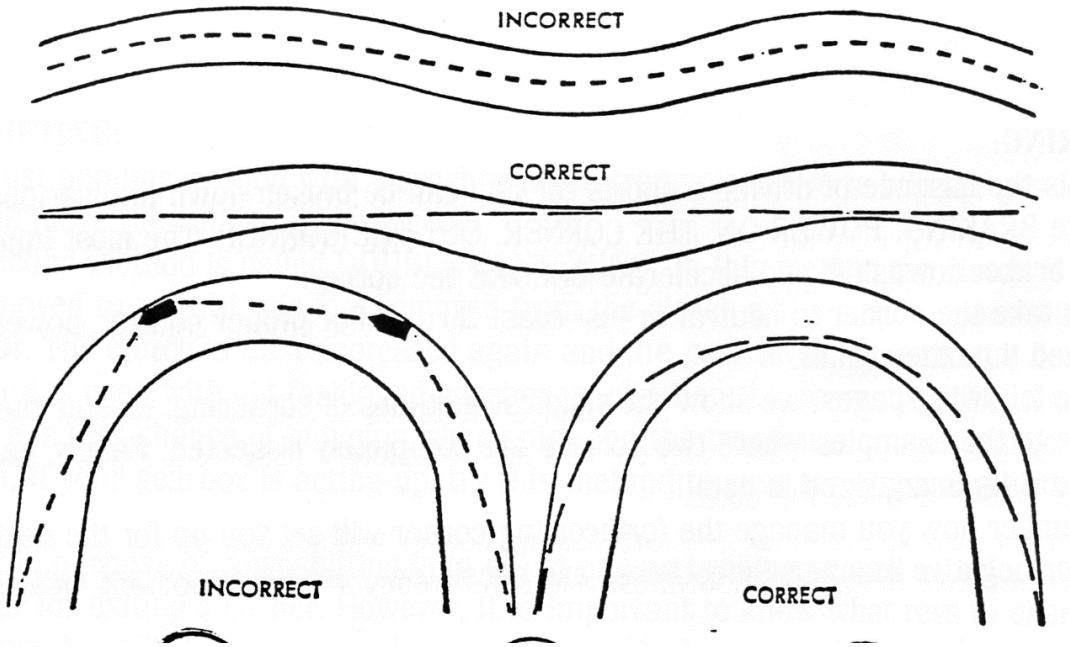
Efficient braking is always done in a straight line just short of locking the wheels. However, instead of releasing the brakes as soon as you begin the corner, continue to use the brakes as you turn in for the turn. As your cornering force increases, your braking force should decrease. This technique keeps the outside front tire patch loaded allowing for better adhesion and therefore, allowing the car to better "point" into the turn, decreasing the tendency to understeer.

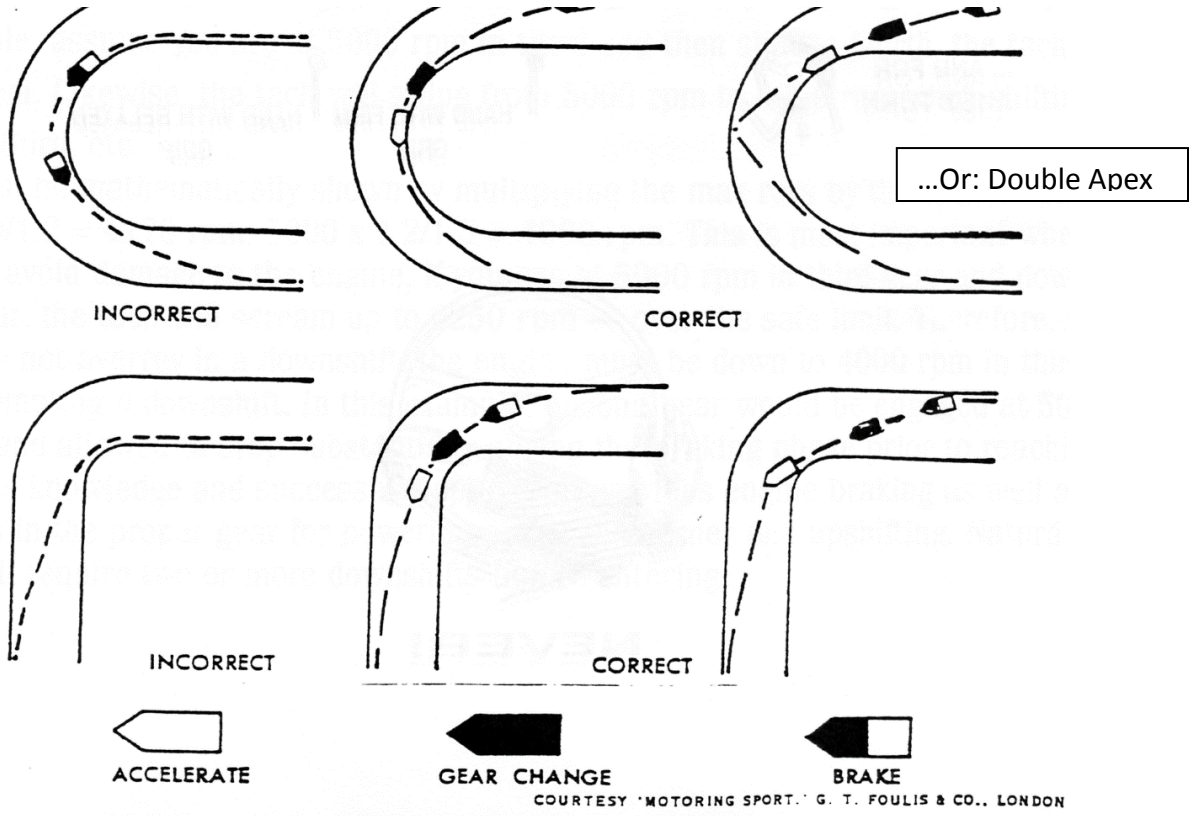
This technique used in conjunction with the proper "line" technique will make the car much more controllable and safer in a cornering situation.

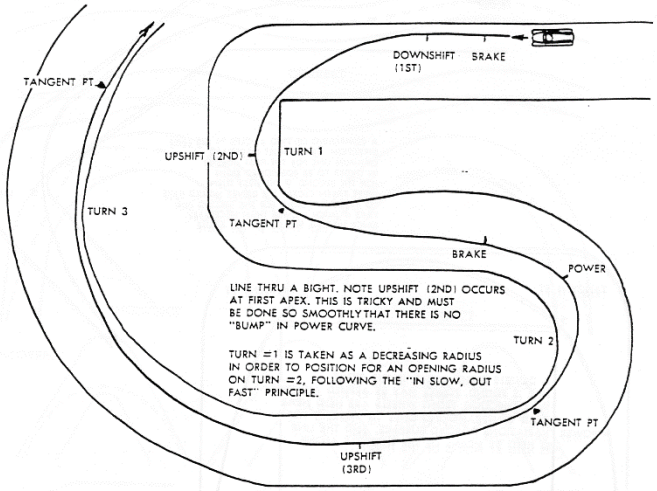


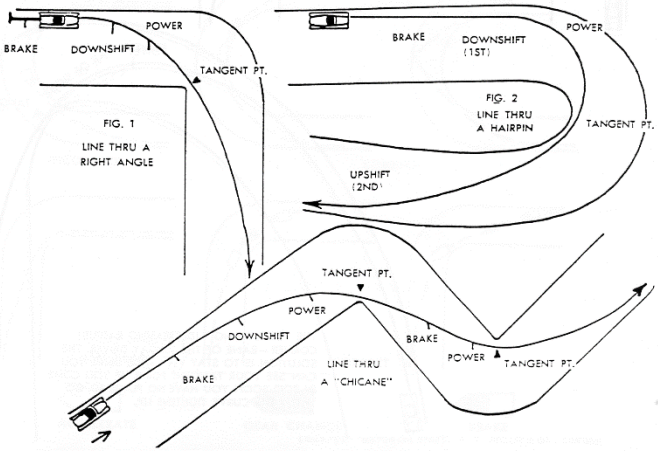


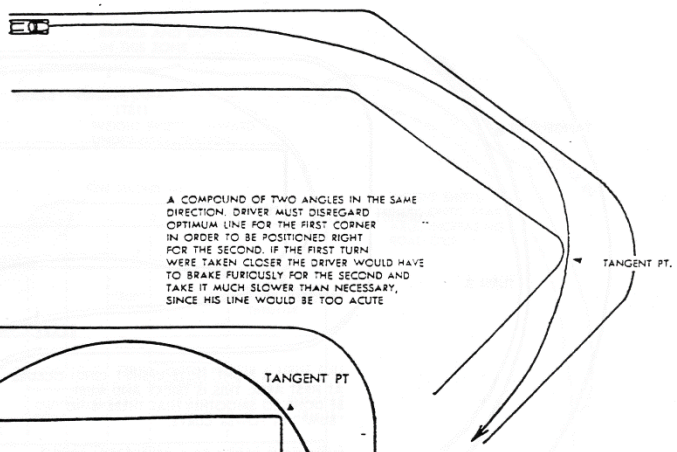
THE LINE

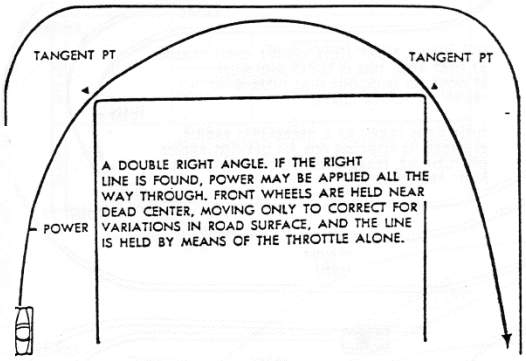

INCORRECT
CORRECT
INCORRECT
CORRECT

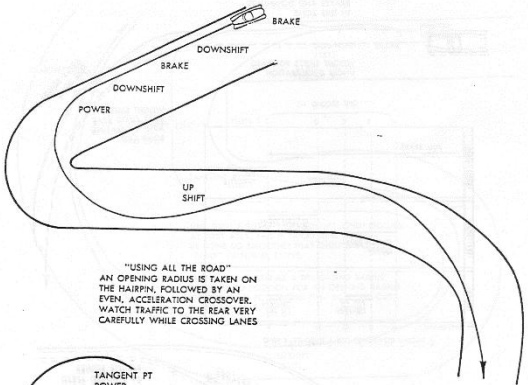

…Or: Double Apex
INCORRECT
CORRECT
INCORRECT
CORRECT
ACCELERATE
GEAR CHANGE
BRAKE
COURTESY 'MOTORING SPORT.' G. T. FOULIS & CO., LONDON

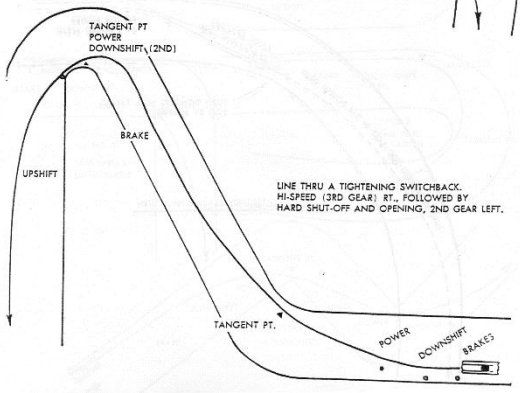

TANGENT PT.
DOWNSHIFT (1ST)
BRAKE
UPSHIFT (2ND)
TURN 1
TURN 3
TANGENT PT
BRAKE
POWER
LINE THRU A BIGHT. NOTE UPSHIFT (2ND) OCCURS AT FIRST APEX. THIS IS TRICKY AND MUST BE DONE SO SMOOTHLY THAT THERE IS NO "BUMP" IN POWER CURVE.
TURN 2
TURN #1 IS TAKEN AS A DECREASING RADIUS IN ORDER TO POSITION FOR AN OPENING RADIUS ON TURN #2, FOLLOWING THE "IN SLOW, OUT FAST" PRINCIPLE.
TANGENT PT
UPSHIFT (3RD)

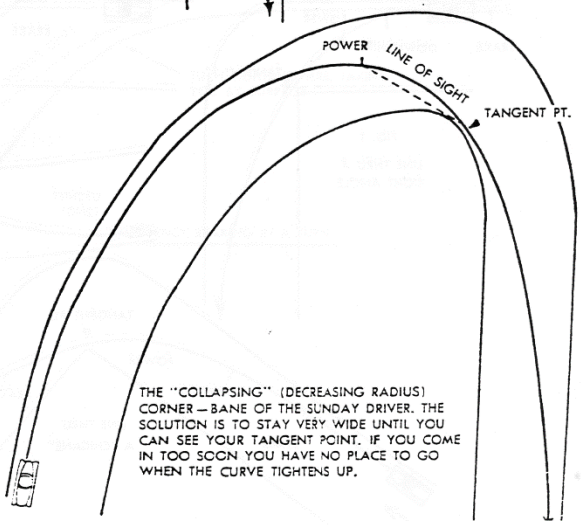

POWER
BRAKE
DOWNSHIFT
TANGENT PT.
FIG. 1
LINE THRU A RIGHT ANGLE
BRAKE
DOWNSHIFT (1ST)
POWER
FIG. 2
LINE THRU A HAIRPIN
TANGENT PT.
UPSHIFT (2ND)
TANGENT PT.
POWER
DOWNSHIFT
BRAKE
LINE THRU A "CHICANE"
BRAKE
POWER
TANGENT PT.


A COMPOUND OF TWO ANGLES IN THE SAME DIRECTION. DRIVER MUST DISREGARD OPTIMUM LINE FOR THE FIRST CORNER IN ORDER TO BE POSITIONED RIGHT FOR THE SECOND. IF THE FIRST TURN WERE TAKEN CLOSER THE DRIVER WOULD HAVE TO BRAKE FURIOUSLY FOR THE SECOND AND TAKE IT MUCH SLOWER THAN NECESSARY, SINCE HIS LINE WOULD BE TOO ACUTE
TANGENT PT.


TANGENT PT
TANGENT PT
A DOUBLE RIGHT ANGLE. IF THE RIGHT LINE IS FOUND, POWER MAY BE APPLIED ALL THE WAY THROUGH. FRONT WHEELS ARE HELD NEAR DEAD CENTER, MOVING ONLY TO CORRECT FOR VARIATIONS IN ROAD SURFACE, AND THE LINE IS HELD BY MEANS OF THE THROTTLE ALONE.
POWER


BRAKE
DOWNSHIFT
BRAKE
DOWNSHIFT
POWER
UP SHIFT
"USING ALL THE ROAD" AN OPENING RADIUS IS TAKEN ON THE HAIRPIN, FOLLOWED BY AN EVEN, ACCELERATION CROSSOVER. WATCH TRAFFIC TO THE REAR VERY CAREFULLY WHILE CROSSING LANES


TANGENT PT
POWER
DOWNSHIFT (2ND)
BRAKE
UPSHIFT
LINE THRU A TIGHTENING SWITCHBACK. HI-SPEED (3RD GEAR) RT., FOLLOWED BY HARD SHUT-OFF AND OPENING, 2ND GEAR LEFT.
TANGENT PT.
POWER
DOWNSHIFT
BRAKES


POWER
LINE OF SIGHT
TANGENT PT.
THE "COLLAPSING" (DECREASING RADIUS) CORNER—BANE OF THE SUNDAY DRIVER. THE SOLUTION IS TO STAY VERY WIDE UNTIL YOU CAN SEE YOUR TANGENT POINT. IF YOU COME IN TOO SOON YOU HAVE NO PLACE TO GO WHEN THE CURVE TIGHTENS UP.

GUIDELINE OF LEARNING ASPECTS IN DIFFERENT RUN GROUPS

(what capabilities, skills and experiences trigger promotion to next group)

Green / Beginner group:

- Seating and Steering wheel position
- Awareness and understanding of corner working locations
- Flagging: Understanding & proven application (e.g. come to controlled stop under "Red")
- Understanding of cone set up (entrance, apex, exit) and "The perfect line": apex, late apex
- Smoothness and Consistency
- Becoming familiar with manual shifting

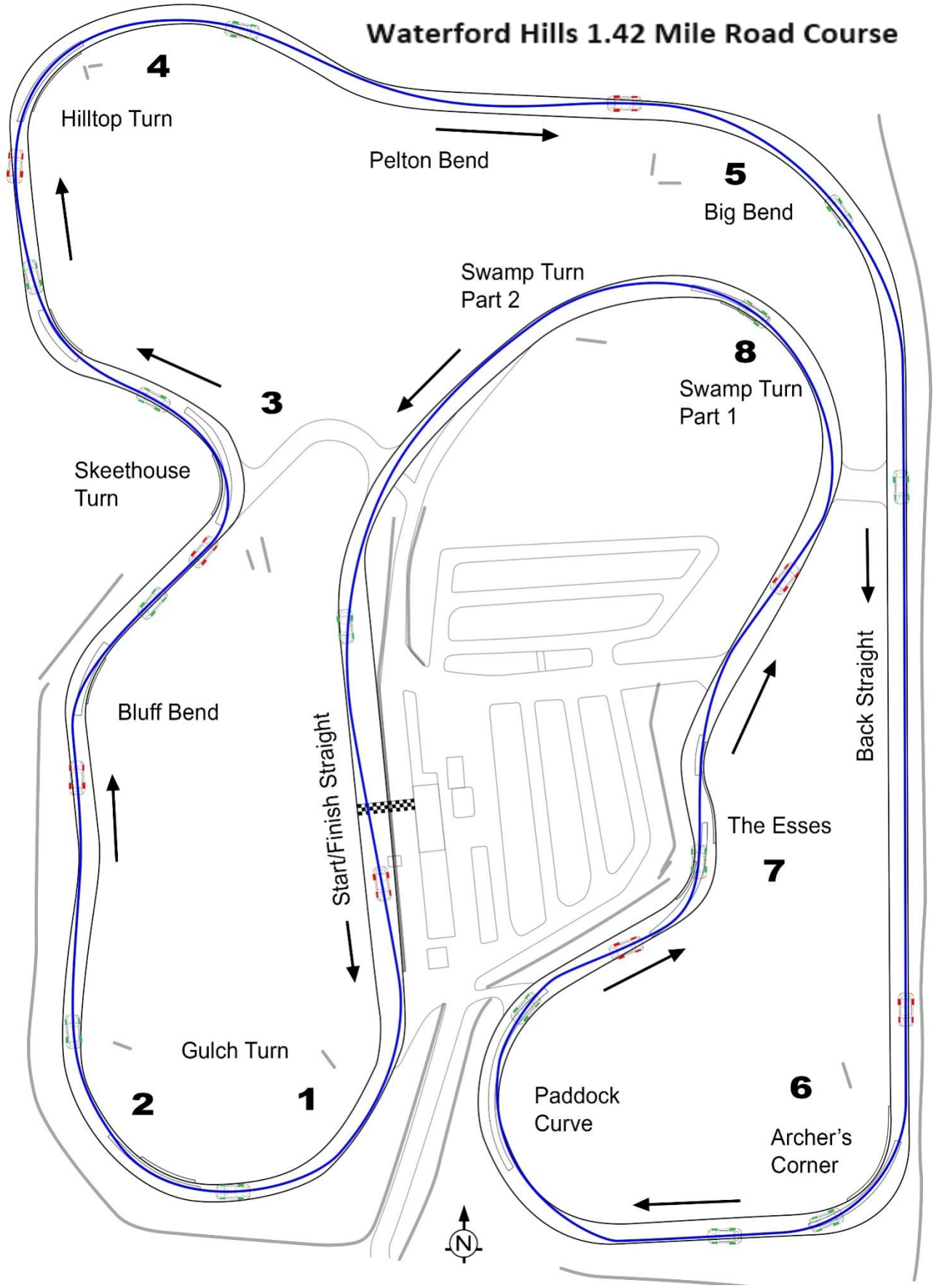
Yellow / Intermediate group:

- Sophistication of "The perfect line" in terms of repeating accuracy and consistency
- Proven improvement of focus, concentration and discipline
- Developed and proven improvement of smoothness & consistency for all 3 inputs (Steering, Throttle, Brakes) while gaining speed, staying safe and remaining in "comfort zone"
- Capable of threshold / ABS braking
- Master of manual shifting, or introduced to / being able to "paddle shift / manual mode" for automatic transmissions (PDK, SMG, etc.)
- Introduction of "Vehicle dynamics and the 3 rotational axes- Roll / Pitch / Yaw" and "Weight transfer while braking, accelerating and turning"
- Introduction of "The friction circle"
- Introduction of advanced driving techniques: Understeer / Oversteer / Trailbraking / Heel and Toe - Blipping Throttle / Left Foot Braking

Blue / Advanced group:

- Instructor advice and input only required for 'fine tuning' already well established driving.
- Master of "The perfect line": Always correct, always consistent, fast, always concentrated, disciplined, in control and safe
- Start to experience other / different track layouts (Gingerman, Mid-Ohio, Mosport, etc.)
- Capable of applying advanced driving techniques such as "understeer, oversteer, trailbraking, heel and toe (blipping throttle), perfect manual shifts, left foot braking, perfect threshold braking", and master consistent/gradually increasing throttle input through turns
- Remaining in "comfort zone", even under stress and extreme driving maneuvers such as oversteering, understeering, skids and drifts
- Full knowledge and understanding how to resolve critical driving situations and what techniques have to be applied in order to get safely out of such situations (e.g. determined throttle input during oversteer)
- Knowledge, understanding and application of "The friction circle"
- Knowledge, understanding and application of "Vehicle dynamics and the 3 rotational axes pitch, roll and yaw"
- Basic understanding of different vehicle and drivetrain layouts and what differences those make in terms of driving characteristics, style and vehicle dynamics (front engine/front wheel drive; front engine/rear wheel drive; rear engine/rear wheel drive; all wheel drive)

TRACK MAP


Waterford Hills 1.42 Mile Road Course
4
Hilltop Turn
Pelton Bend
5
Big Bend
Swamp Turn
Part 2
8
Swamp Turn
Part 1
3
Skeethouse
Turn
Bluff Bend
Start/Finish Straight
Back Straight
The Esses
7
Gulch Turn
2
1
Paddock
Curve
6
Archer's
Corner
N

TERMS

TRACK TERMS:

APEX - The part of a corner where the racing line is nearest the inside of the bend

ESSES - Sequences of alternating turns on a road course resembling the letter 'S'

PIT LANE or HOT PITS–Runs parallel to the main straight, where cars line up in a grid prior to entering the track

PADDOCK - An enclosure at a track used by team support personnel and vehicles (as well as other officials and VIPs)

VEHICLE SETUP TERMS:

CAMBER - The amount a tire is tilted in or out from vertical; described in degrees, either positive or negative. If a wheel is perfectly perpendicular to the surface, its camber would be 0 degrees. Camber is described as negative when the top of the tires begin to tilt inward towards the fender wells. Consequently, when the top of the tires begin to tilt away from the vehicle it is considered positive. Zero camber will result in more even tire wear over time, but may rob performance during cornering. Ultimately, optimal camber will depend upon your driving style and conditions the vehicle is being driven in.

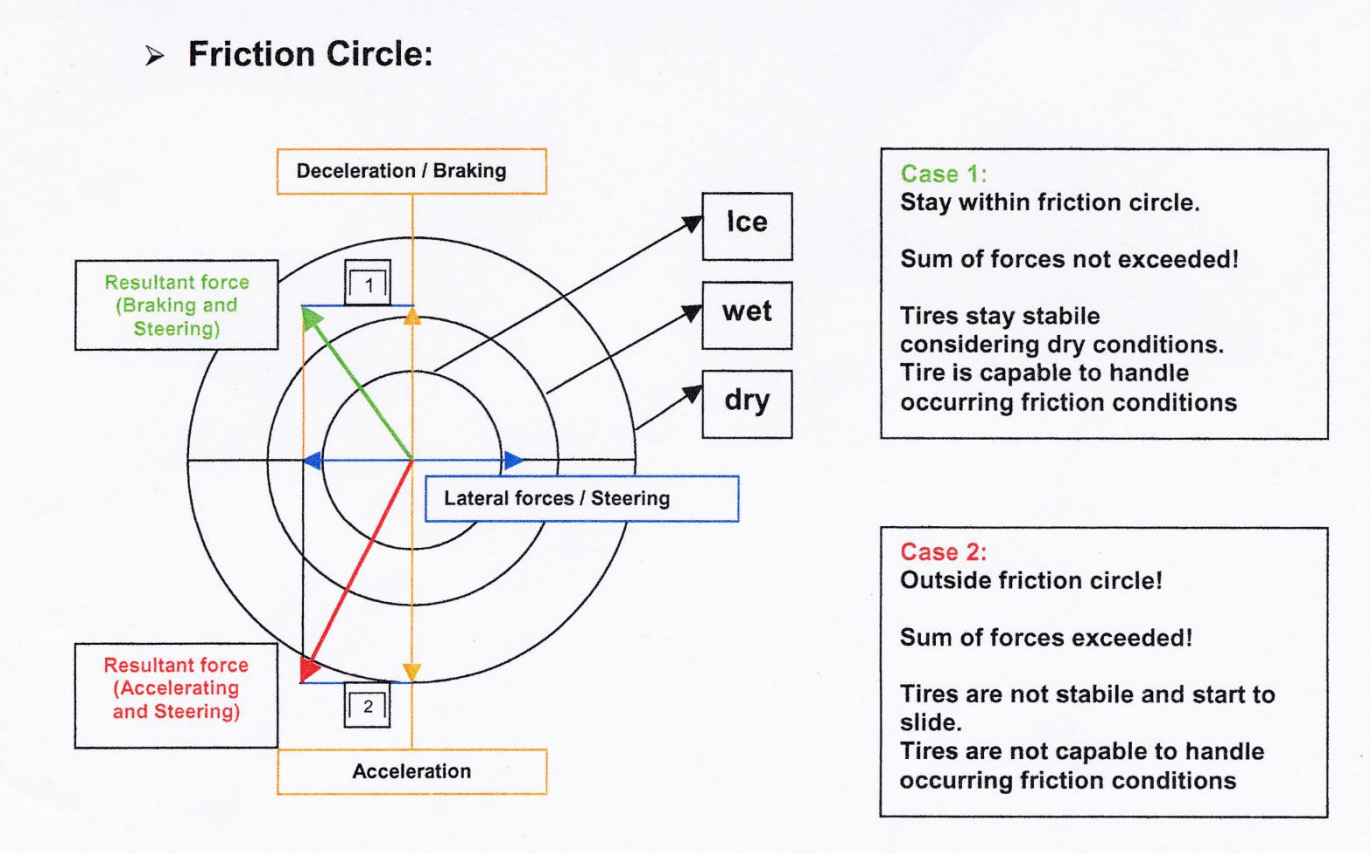
CASTER - Caster is a bit harder to conceptualize, but it's defined as the angle created by the steering's pivot point from the front to back of the vehicle. Caster is positive if the line is angled forward, and negative if backward.
Typically, positive caster will make the vehicle more stable at high speeds, and will increase tire lean when cornering. This can also increase steering effort as well.
Most road vehicles have what is called cross-caster. Cross castered vehicles have slightly different caster and camber, which cause it to drift slightly to the right while rolling. This is a safety feature so that un-manned vehicles or drivers who lose steering control will drift toward the side of the road instead of into oncoming traffic.

TOE - Looking at the car from the front, the amount the tires are turned in or out. If you imagine your feet to be the two front tires of a race car, standing with your toes together would represent toe-in. Standing with your heels together would represent toe-out.

- Correct toe is paramount to even tread wear and extended tire life. Sometimes however, tread life can be sacrificed for performance or stability
- Positive toe occurs when the front of both tires begins to face each other and creates straighter driving characteristics
- Negative toe increases a cars cornering ability while decreasing straight line stability as a result

VEHICLE DYNAMICS TERMS:

FRICTION CIRCLE (or "Kamm'sche circle") - "In a defined curve or radius we can only brake as much as the result (vector) of curve radius and brake is defined by the max. outer circle of the friction circle". "At the limit" this means: we reach or exceed the outer area of the friction circle. "Transition from grip to skid"! Influencing factors of the outer area of the friction circle are: Road surface, tires and tire condition, car behavior. Example of holding a vertical long stick in your hands: An instable situation can be controlled, depending on some conditions. We learn that it is going to be easier to correct the instable vertical stick by increments of movements, instead of waiting in what direction it might want to fall to and corrections might be too late. That's considered the real artistic at the steering wheel, the balancing act.



PUSH - When the front tires are not getting enough grip on the racetrack. This causes the car to want to continue straight ahead when the driver turns the wheel. Also could be considered UNDERSTEER

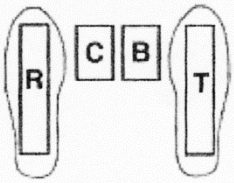
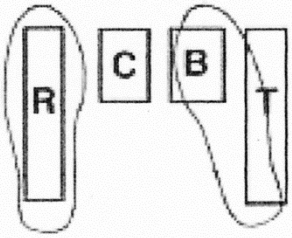
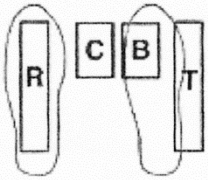
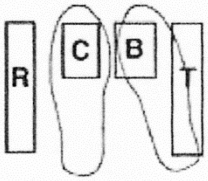
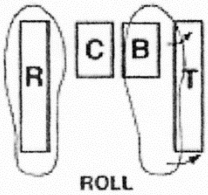
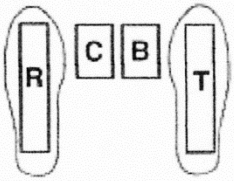
LOOSE - This is when the front tires are getting a better grip on the racetrack than the rear tires. This causes the back end of the car to want to come around in the turns making the nose of the car point towards the inside of the corner. Also considered OVERSTEER

UNDERSTEER - A front wheel skid, loss of steering control

OVERSTEER - A rear wheel skid or slide

TRAILBRAKING – Braking (or lifting throttle) <u>while</u> steering into a turn

HEEL AND TOE SHIFTING - A driving technique used mostly in performance driving although some drivers use it on the road in everyday conditions in the interest of effectiveness. It involves operating the throttle and brake pedals simultaneously with the right foot, while facilitating normal activation of the clutch with the left foot. It is used when braking and downshifting simultaneously (prior to entering a turn), and allows the driver to "blip" the throttle to raise the engine speed and smoothly engage the lower gear.

Cruise In 3rd Gear		
Brake Approaching Turn		"BIG FOOT" ALTERNATIVE 
SEQUENCE: • Clutch In • Transmission Passing Through Neutral* • "Blip" Throttle • 2nd Gear		 ROLL RIGHT FOOT
SEQUENCE: • Release Clutch • Accelerate/Cruise in 2nd Gear		

NOTES

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