Race-car tuning cribsheet

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Abstract—**Race cars have many settings that can be adjusted or "tuned" to decrease lap times, either by improving acceleration, cornering, and braking, or by making the car easier to drive. Each setting has both helpful and harmful effects.**

Print page two of this document for convenient reference while playing simulations like Gran Turismo (www.gran-turismo.com).

INTRODUCTION

No setting applies universally to every car on every track. Tuning presumes a particular driver, car, track, and tire compound.[1] Track aspects that affect tuning are bumpiness, height of curbing and rumble strips, length of straights, and layout of corners.

Lap times are often limited more by tire grip than by horsepower or braking. Thus, tuning tries to let all four tires contribute to acceleration, cornering, and braking. Tuning has more effect on tall short cars, which suffer more from load transfer.

At each step of tuning, *observe* how and where this car misbehaves worst on this track. Misbehavior may mean loss of grip (wheelspin), difficult handling, or any of the dozens of symptoms listed on page two.

DEFINITIONS

A. Steering

Understeer / Oversteer / Balanced: the front tires grip less / more / the same as the rear, in some context.

Power understeer: while cornering, *increasing* throttle unloads the front, widening the turn.

Lift-off oversteer (trailing-throttle oversteer, snap oversteer): while cornering, suddenly *releasing* throttle unloads the rear, swinging the rear out. Can be a panic overcorrection to power understeer. When maintained deliberately, this is called drifting.

Turn-in / Turn-out: entering and exiting a corner.

B. Braking

ABS: anti-lock braking. Easier to control but weaker than properly balanced brakes.

C. Alignment

Toe-in (at front or rear): tires' fronts are closer to each other than their rears.

Negative camber (at front or rear): tires' tops are closer to each other than their bottoms.

D. Load transfer ("weight transfer")

Roll: lowering of outer side while cornering. When large, this changes effective camber, which shrinks the contact patch and thus reduces grip.

Bottom-out: compressed spring hitting its limit, reducing grip because that tire stops tracing road irregularities.

SUSPENSION

Because springs affect everything, adjust their stiffness before fine-tuning subtler things like alignment or anti-roll bars, which are like springs that affect only cornering.

In particular, adjust over/understeer first by changing the front-back difference in spring stiffness. Here's why this works (although you could just try it and see). In a constant-radius constant-speed turn, load transfer is purely sideways, no matter what the difference in front-rear stiffness is. If you stiffen the rear springs, then, this purely sideways load transfer unloads the inside rear tire and loads the outside rear. So the outside *front* gets *less* load. That reduces the difference between the front tires' loads. Spreading the load better across the front tires increases their grip, which is the definition of oversteer.

ACKNOWLEDGEMENTS

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[1]In GT4, N2 tires best mimic real-world behavior.

BRAKE BALANCE CONTROLLER

First, minimize straight-line braking distance. In GT4, start with 3:1 or 4:1 (FWD, 5:1 or 6:1). On the Test Course, measure several decelerations from your track's expected top speed to its slowest speed.

To avoid ABS:	Reduce front and rear.
To over/understeer:	In/decrease rear vs. front.

SPRINGS

To over/understeer:	Soften/stiffen front vs. rear.
To grip bumpy corners:	Soften front.
To reduce wheelspin:	Soften driven end.

RIDE HEIGHT

Lower means stabler, especially when rolling from one corner to the next (until bottom-out, or the chassis scrapes the road).

Raising one end is like stiffening that end's springs and anti-roll bar.

To reduce load transfer in braking, accelerating, and cornering:	Lower (& stiffen springs).
To grip bumps:	Raise (& soften springs).
To over/understeer:	Raise/lower rear vs. front.
To load front brakes more (for mid-engine cars):	Raise rear.

DAMPERS

(Also called shock absorbers.)
Stiffen the end with the drive wheels.
Make rebound stiffer than bound.

To smoothen transition to over/understeer:	Stiffen.
To grip over bumps:	Soften.
To over/understeer at turn-in:	Stiffen/soften front bound & rear rebound.
To over/understeer at turn-out:	Stiffen/soften front rebound & rear bound.
To feel road roughness:	Stiffen bound.
To bounce less from bumps:	Stiffen rebound.
To avoid bottom-out and feel bumps less:	Soften rebound.

NEGATIVE CAMBER

To grip corners (with large body roll):	Increase.
To brake hard and stably:	Reduce (especially front).
For straight-line grip and stability:	Reduce at drive wheels.
To over/understeer slightly:	In/decrease front vs. rear.

TOE

In GT4, + is toe-out, − is toe-in. In GT5, the reverse.

To over/understeer:	In/decrease rear.
To over/understeer at turn-in:	In/decrease front.
For stability, esp. when braking or "two wheels off":	Decrease front (and rear slightly).

ANTI-ROLL BARS

(Also called sway bars or stabilizer bars.)
Avoid extremes.

To grip bumps:	Soften.
To reduce dartiness:	Soften.
For lower ride height in steady-state turn:	Stiffen.
To over/understeer:	Stiffen/soften rear vs. front.

DOWNFORCE

Above 60 mph, handling is affected more by downforce than by suspension settings or weight balance. Below 60 mph, these settings have little effect.

For grip, stronger braking, and stabler high speed:	Increase (and stiffen springs).
To increase top speed:	Reduce (and soften springs).
To over/understeer :	In/decrease front vs. rear.

GEAR RATIOS

Reach maximum rpm in top gear only near the end of the longest straight.

In GT4, just adjust the "auto slider" and final ratio.

To accelerate harder:	Decrease final and/or auto.
To increase top speed and reduce wheelspin:	Increase final and/or auto.

LIMITED SLIP DIFFERENTIAL

This affects only the driven wheels.

In GT4, a value of 5 means a road car's open differential, while 60 means a locked differential. Accel/decel values have little effect near either extreme, or if initial torque is high.

To brake stably at turn-in:	Increase decel.
To grip at turn-out:	Increase accel.
To grip tight turns:	Decrease accel & decel.
To maneuver better:	Decrease initial torque.

VARIABLE CENTER DIFFERENTIAL

(Also called torque-sensing.) Divides 4WD torque between front and rear. More effective on pavement than dirt.

In GT4, for RWD handling:	Reduce.
In GT5, to over/understeer:	In/decrease rear torque.