Racecar 101

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Outline

Note

This first part is a very simplified breakdown

- It's not the most accurate
- It's not to insult anyone's intelligence

It's simply to not distract from the things that can be easily forgotten or muddied.

What makes a car go fast?

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To make a car **faster**, you must make the car **accelerate more**

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What famous equation involves acceleration?

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Newton's 2nd law!

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We care about acceleration, so rearange:

$$a = \frac{F}{m}$$

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The latter two hold **only if the tires can transfer the torque**

Balancing $\uparrow$Force vs $\downarrow$Mass

Sometimes $\uparrow$ mass $+$ $\uparrow$ force $=$ $\uparrow$ acceleration

Balancing $\uparrow$Force vs $\downarrow$Mass

Sometimes $\uparrow$ mass + $\uparrow$ force = $\uparrow$ acceleration

Bigger Engine

Increases the total vehicle mass, but increases power output
Depending on the ratio, can lead to better acceleration.

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Smaller/Narrower Tires

Decreases total vehicle mass, but decreases total acceleration potential
Also reduces unsprung mass (improves vehicle handling and response)

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2. Power (positive)
    - Almost always limited by the power unit (ICE, electric motor, rubber band windup, etc.)

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Therefore given:

- a force, F (tire traction)
- a mass, m (the car)
- and a radius, r (the track/racing line)

there is a **limit to the maximum velocity**

Lateral Acceleration cont.

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   - How?

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   - How?
     - Aero downforce
     - Different tires
     - Suspension design, etc....

Quick Review

Higher Acceleration = Faster Car

	Limited by	How to make better?
Longitudinal Acceleration	Force (Braking and Power)	Bigger Engine/Brakes
	Mass	Reduce it
Lateral Acceleration	Force (Tire Traction)	Increase Grip
	Mass	Reduce it

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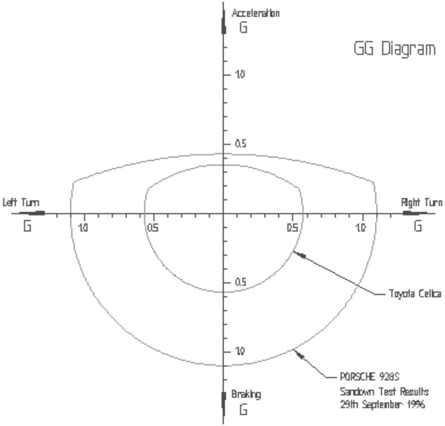

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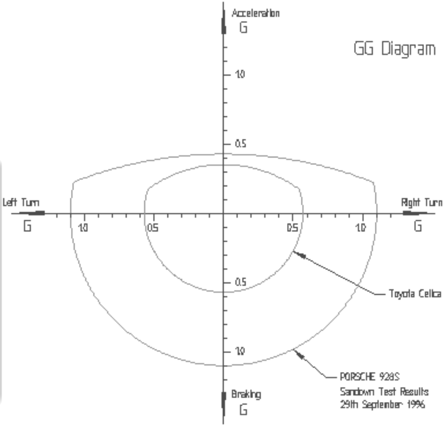
G-G Curve (or Traction Circle)

- Plots **maximum steady-state acceleration** that a vehicle can have in **any direction**



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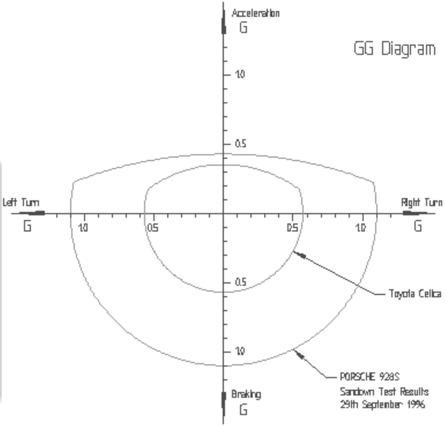

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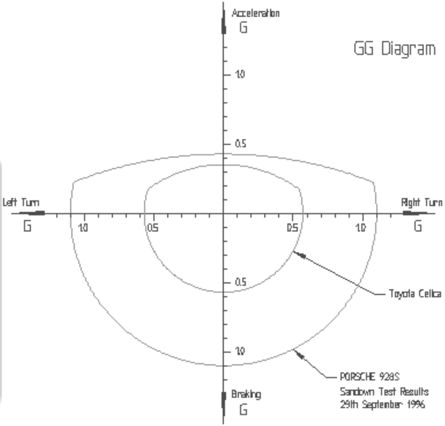

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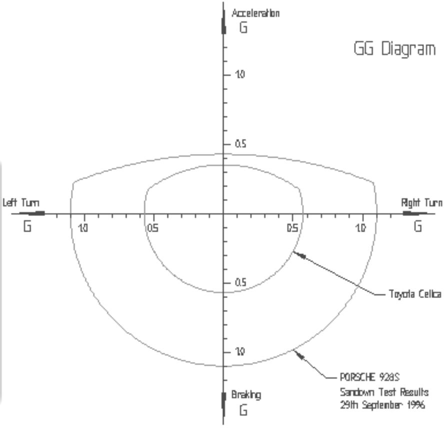
- On the circle = driving at the edge



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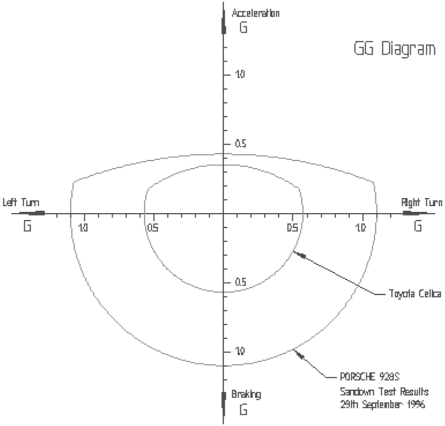
G-G Curve: Misc Remarks

- Circles



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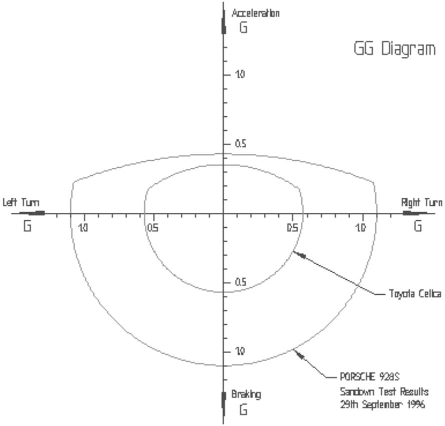

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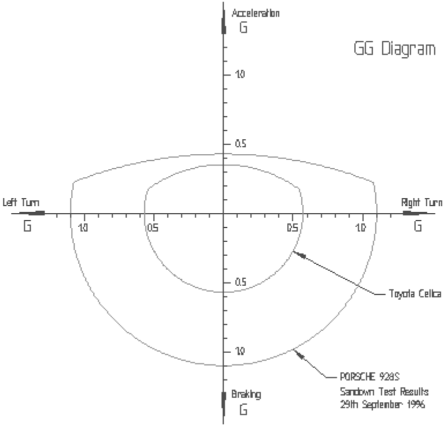

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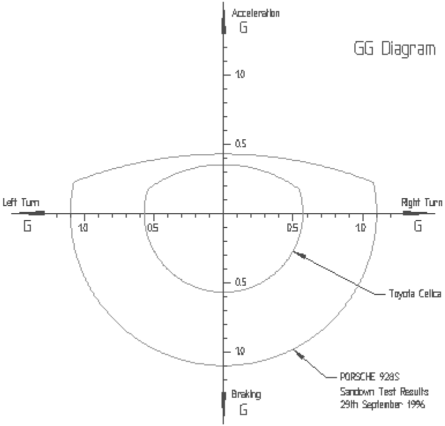

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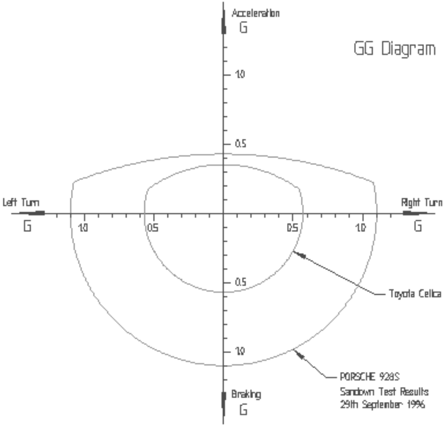

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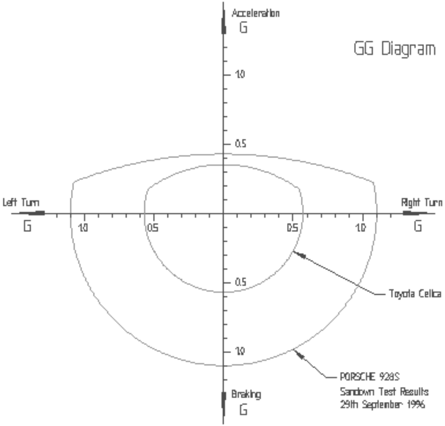
  - **Positive acceleration is nearly always limited by the power unit, not the tires**
  - For (nearly) all cars, the power unit is the most severe acceleration limitation.



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Via friction with the ground

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- μ is generally assumed to be constant
  - So F is linearly dependent on N

Tires and Load Sensitivity

- Tires **do not** have a constant μ:

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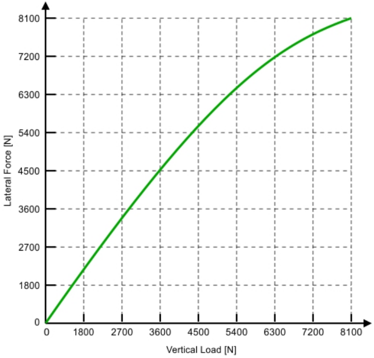

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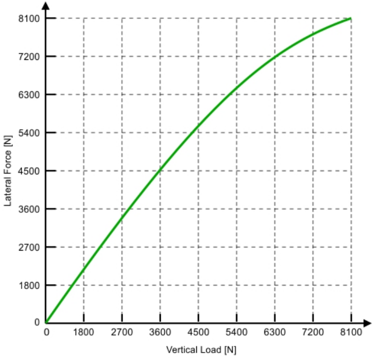

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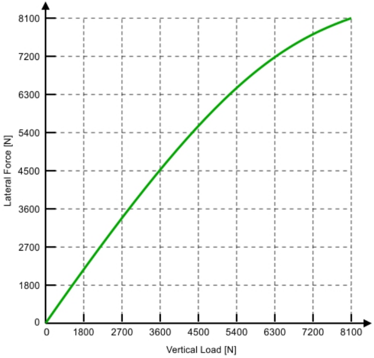

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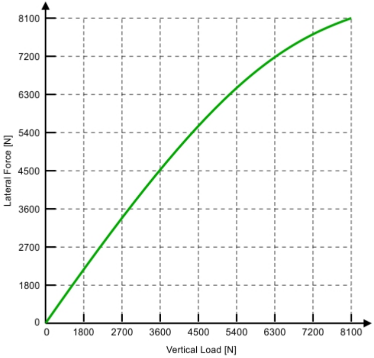

Load Sensitivity is the singular most impactful thing in racecar design

It alters practically every single decision