

Use of Roll stiffness distribution as a guide to setup

A simple method of assessing the effect of spring and anti-roll bar changes on the handling of a specific car is to determine the roll stiffness distribution of the car with a known and desired handling balance.

Whatever changes are then introduced to change roll stiffness this distribution can be used to return the car to the original handling balance albeit at a different total roll stiffness level.

Data for 2003 WRC Imprezza

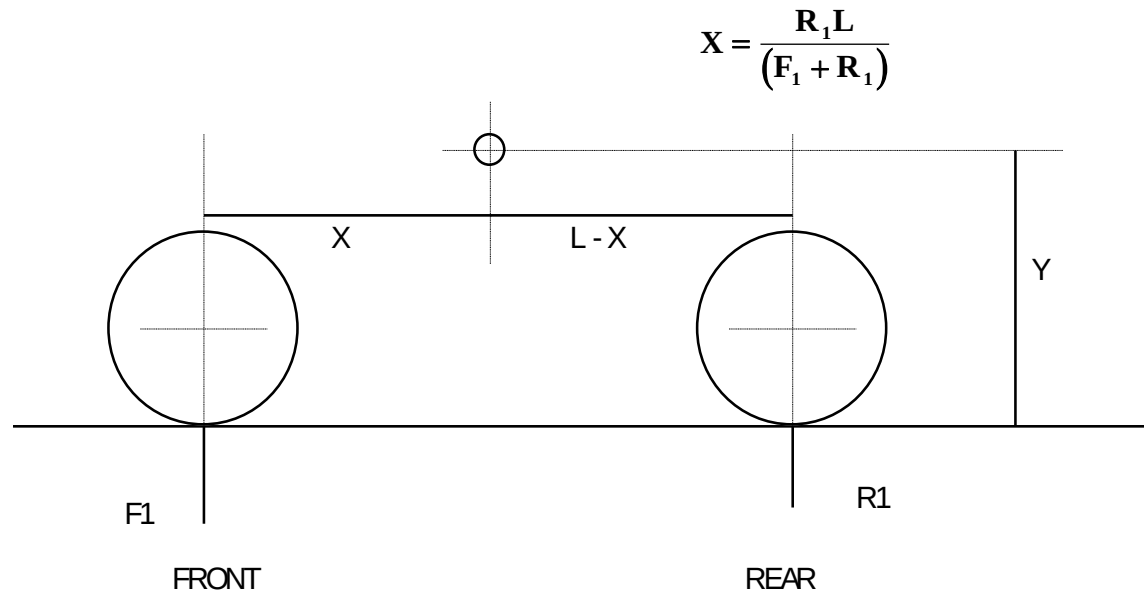
VEHICLE FIGURES			
CHASSIS		Front	Rear
	Total mass (kg)	1370	
	Weight distribution F-R (%)	54.7	
	Unsprung Mass F-R (kg)	57	45
	Unsprung CofG height (mm)	325	320
	CofG Height (mm)	410	
	Wheel Base (mm)	2544.5	
	Track (F-R) (mm)	1559	1583
SUSPENSION	Spring Rate (N/mm)	60	55
	Tyre Stiffness (N/mm)	500	500
	Roll Centre (mm)	-52.4	20
ARB	External Diameter (mm)	28	28
	Internal Diameter (mm)	0	0
	Setting	h	h
RESULTS			
Natural Frequency(hertz)		2.26	2.29
Ratio of Frequencies (R/F)		1.02	
% Roll Stiffness		33.28	66.72
Roll Angle per G (°/g)		1.56	
Cranfield method of Roll Angle per G		1.64	

If this exercise is repeated for the Locost the balance that we have found gives a balanced car is a front roll stiffness of close to 47% of the total roll stiffness compared to 33% for the Imprezza.

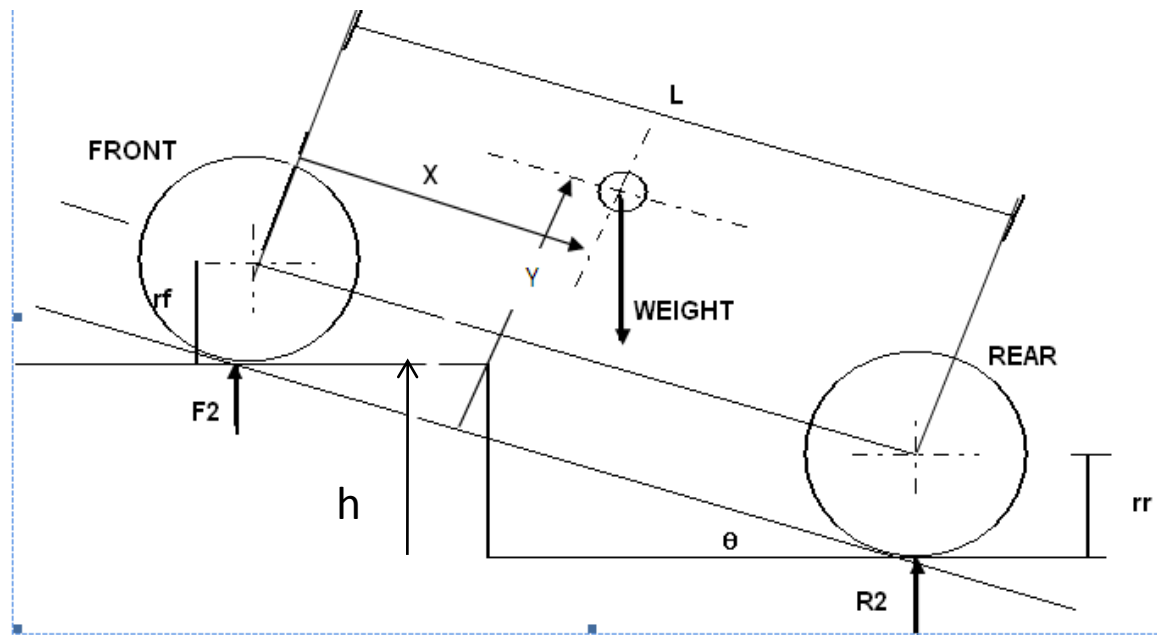
Consider the differences in these two cars and why the values are so different.

Finding the CG of a vehicle

Use corner weight scales to find F_1 and R_1 and hence X on diagram



Lift front of vehicle so that front wheels are at height h and re - weigh to find $F2$ and $R2$. The higher the front wheels can be lifter the more accurate the result



Centre of gravity height Y

$$Y = \frac{R_2 \times h}{[(R_2 + F_2)\sin\theta \tan\theta]} - \frac{X}{\tan\theta} + r_f + X \frac{(r_r - r_f)}{L}$$

Further Refinements

The work so far has looked at steady state load distribution from spring and anti roll bars.

Consider the other forces that would influence the load distribution

The most significant will be aero forces and damping forces.

Aero Effects on vertical load distribution

Example of ride height changes on Aero Effects for an Indy Car

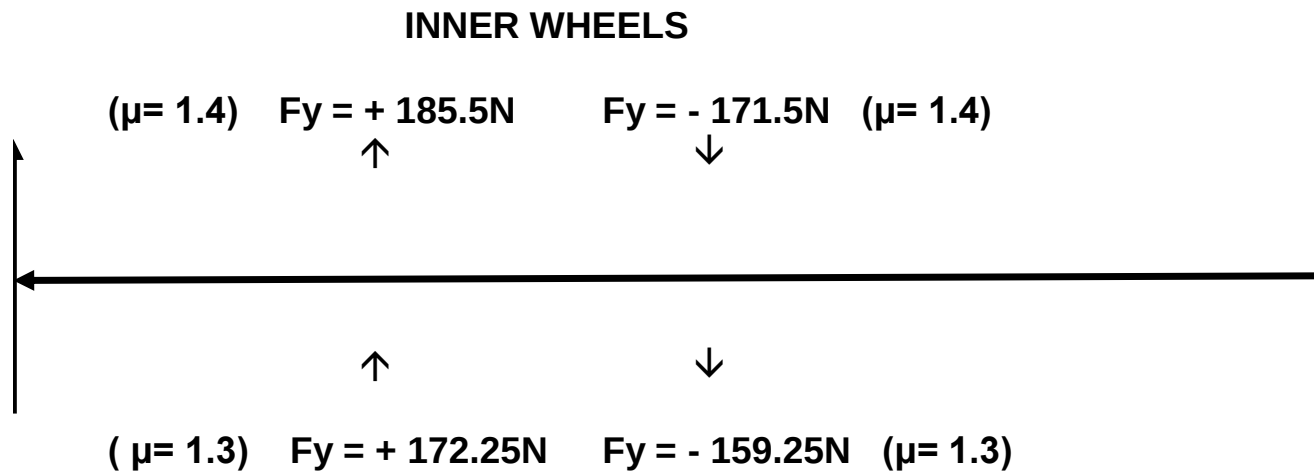
Front Ride height 3.1 mm in each of the cases below. The table shows the effect of changing the rear ride height from 31.7mm and 41.3mm

	Rear Ride Height	
Total Aero load	31.7mm	41.3 mm
% Front	41.67 %	43.37 %
Aero Down force		
Front	6280 N	6545 N
Rear	8790 N	8545 N
Change in F_z		
Front	+265 N ie 132.5 N/wheel	
Rear	-245 N ie 122.5 N/wheel	

Aero induced lateral force changes

Effect of these changes on a cornering car.

Assume inner tyres $\mu = 1.4$ and outer tyre $\mu = 1.3$



<u>Lateral Force Change</u>	Front	+358 N	Rear	-330.75 N
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Damping Forces

All the work done so far has been for steady state behaviour. The effect damper will have on load distribution will occur in transient conditions when its low speed characteristics will increase or decrease wheel load.

In a steady state on a smooth track this will not be occurring . However the high speed damping of the unsprung mass will effect the actual grip of the tyre and so influence the handling balance

References

Bastow, D, Howard, G and Whitehead, J (2004) *Car Suspension and Handling*, 4th ed. SAE, Warrendale

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Rowley, W (2005) *An Introduction to Race Car Engineering* 3rd ed. Rowley Race Dynamics, Calgary

Class Exercise



- Using the data you already have for the Locost calculate the individual wheel loads when it is cornering at 0.8 g.
- Assume the car in this trim is a stable neutral steering car in left turns.
- Use the Rowley load distribution table to demonstrate whether you would expect it to understeer more or less when turning right.