

# Suspension Crash Course

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*By Der Bayer*

Hey guys,

I thought I might put together a short suspension crash course for those who might not have too much knowledge about that part of car design. The full "Beginner's Guide to Car Design" still is quite a long way off (that will come after the Car Designer is feature complete), so this can shorten the wait. I hope you enjoy!

What I want to explain:

- which tests are simulated
- what the different graphs say
- what the settings in the suspension tab do

I hope it helps with better understanding of what is happening and maybe even with finding bugs. Feel free to ask here if something remains unclear!

## Tests and Graphs

### Steady state circle test - Yaw rate graph

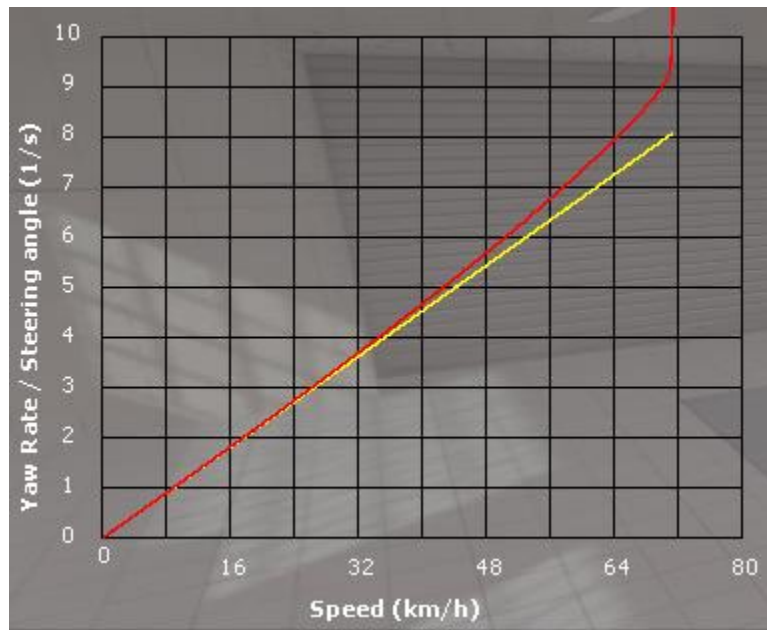
This test simulates a car on a skid pad which is driving in a circle with a radius of 50 meters. It starts very slowly and gets faster step by step. Depending on how the driver has to change the steering wheel angle at the various speeds, it is possible to determine if a car is understeering, oversteering or neutral. If the driver needs to steer more, the car is understeering, if he has to steer less, the car is oversteering.

Neutral is represented by the yellow line in the yaw rate graph. Everything below is "under"steering, everything above is "over"steering.

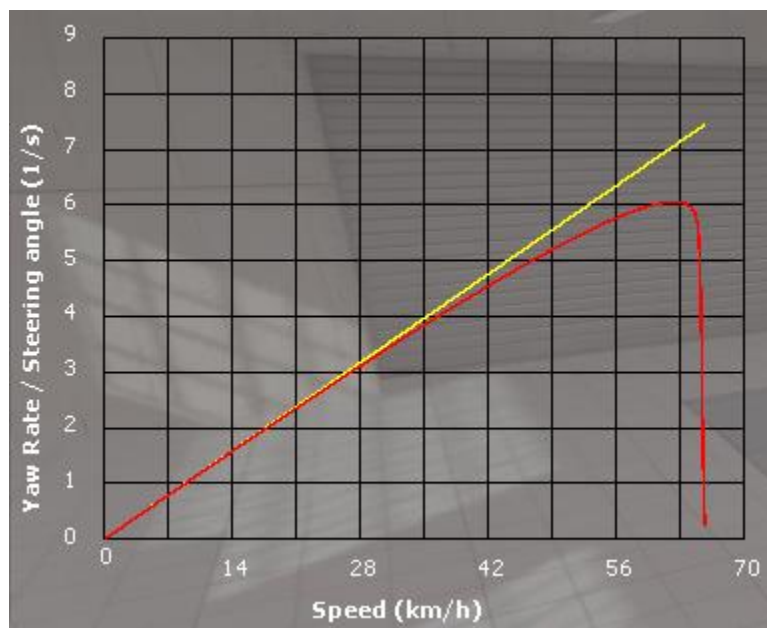
Out of this test you get the maximum lateral acceleration (g-Forces) and, after future updates, an influence on how sporty or tame your car is (depending on over- or understeer).

See the next page for example of oversteer and understeer.

## Oversteer



## Understeer

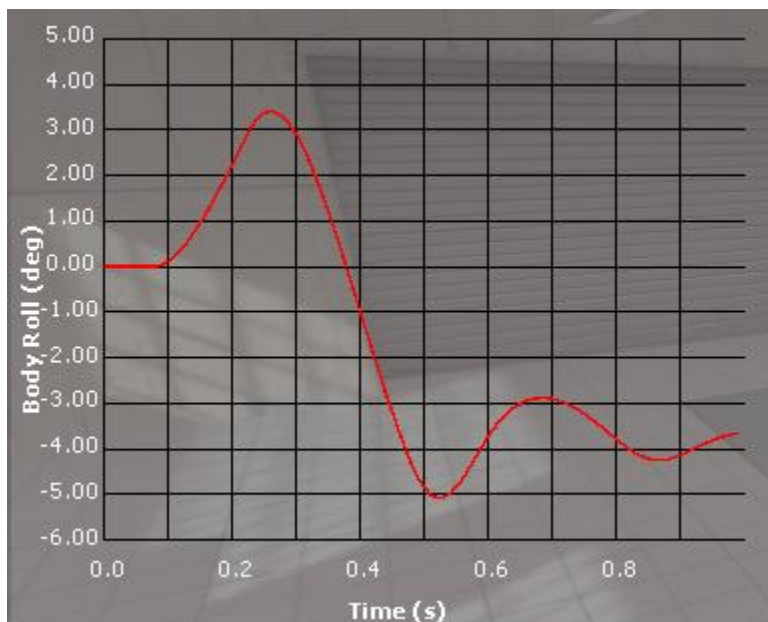


## Body roll test

The body roll test is similar to the moose or fishhook test. The maximum lateral acceleration out of the circle test is taken into account: The car is driving a corner with that acceleration in one direction and pulling to the other direction after a short time. The focus is on the roll angle of the car body. This will first reach positive numbers and then negative ones, levelling off at a certain value.

Out of this test you get the maximum absolute roll angle and if that becomes too big and things like track width, height of center of gravity, roll inertia and suspension roll centres are coming together in a unfortunate way, the car can roll over. Currently, this is quite difficult to achieve, as the fake total weight slider moves down the center of gravity quite a bit.

Big maximum roll angles will be rated not tame and not sporty.

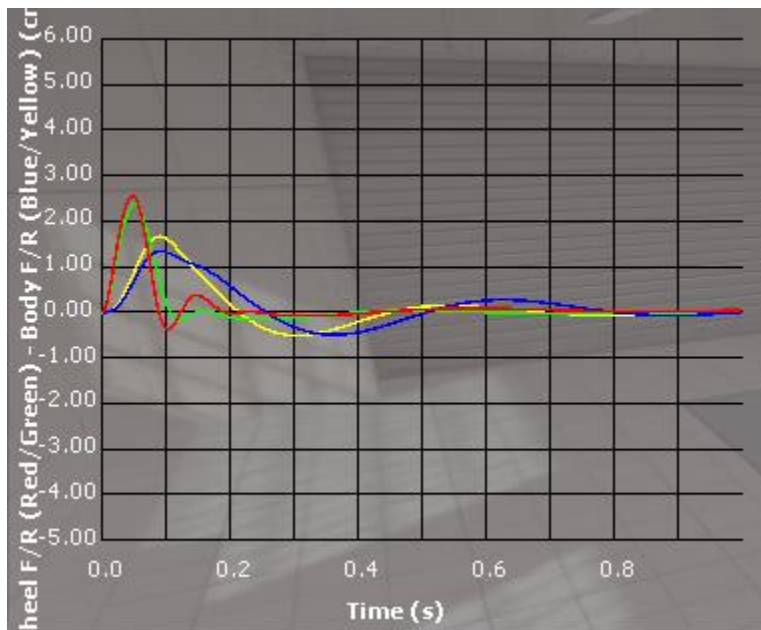


## Body bump test

In this test, the car is driving over a short, 2 cm high obstacle. This bump goes from the road through the wheel and the suspension into the body. Both parallel wheel travel and opposite wheel travel on every axle are simulated (so to stiff sway bars will make the suspension utterly hard for the opposite wheel travel test), but only parallel wheel travel is shown in the graphs.

The movement of front and rear tires is shown with the red and green lines, the body movement at the respective axle with the blue and yellow lines.

Depending on how much of the bump is going into the body and how long it takes to stop moving again, the comfort rating will be good or bad in the future. The stress on the tires (depending on how much the tire moves up and down) will go into tameness. Higher profile tires will be softer and absorb more of the bump than low profile tires.



## Suspension Settings

### Camber [°]

Negative camber can increase the potential side forces of the tires of one axle but will make the tires wear faster. If you have an understeering car and want to make it more neutral, try giving it more negative camber at the front. If you have an oversteering car, give it more negative camber at the rear.

The effect of this can only be seen in the yaw rate graph and the maximum lateral acceleration.

### Springs [N/m]

Harder springs make the car roll less but less comfortable in the bump test. Also, softer springs at the front axle make it understeer less and softer at the rear make it oversteer less.

The effect of this can be seen in all of the three mentioned tests and graphs.

### Dampers [Ns/m]

Dampers try to "dampen" fast body roll and fast wheel travel. So harder dampers will cause less body roll and less stress on the tires in the bump test, but in the car you will notice more of the bump because the suspension gets stiffer.

Effects can be seen in the roll and the bump test, not in the circle/yaw rate test, as this is a static manoeuvre.

### Sway Bars [Nm/rad]

Sway bars make your car roll less by forcing the wheel on the one side of the respective axle to go into the same direction as the wheel on the other side of the axle. This means your suspension will get stiffer at the opposite wheel travel (body bump) test and therefore less comfortable. In addition to that you can influence over- or understeer: Stiffer sway bars will weaken the axle where they are installed. So making the front sway bar harder will make the car understeer, making the rear sway bar harder will make the car oversteer.

Effects can be seen in all three of the mentioned tests.

### Ride Height [mm]

Ride height (together with suspension geometry -> roll centres) has an influence on how much the body rolls. So more ride height will give higher maximum roll angles. In the circle test you might sometimes want a bit more roll angle: The more the body rolls, the more the outside wheels will travel upwards and the more negative camber they can build up (this only is right for certain suspension types, others can behave the opposite way!).

Effects of this can be seen in the roll test, the circle test (and also in acceleration and braking tests, as it influences dynamic weight distribution).

### **Total Weight [kg]**

Higher total weight will make the car more comfortable as the body barely moves when the wheels travel up and down. But it might roll more and will become worse at cornering. The car will probably even need better, stiffer tires to carry the load.

Effects of this can be seen in all three suspension tests as well as in acceleration, braking and fuel economy.

### **Weight Distribution**

Weight distribution has a major effect on over- and understeer, it's nearly as important as the tire parameters. A front-heavy car will barely be able to oversteer (in static maneuvers as the circle test) and vice versa. Also it determines how your spring stiffnesses have to be distributed between front and rear for a smooth ride. It can affect the body roll, too, if different suspensions are fitted to the front and rear axle.

Effects of this can be seen in all three suspension tests as well as in acceleration and braking (dynamic weight distribution).