



Hochschule
Kempten

University of Applied Sciences



ADAS Master WS 21/22

Lecture 8

Vehicle Dynamics in context of Advanced Driver Assistance Systems and Automated Driving.

Lecture program



<https://moodle2.hs-kempten.de/moodle/course/view.php?id=2914>

Nr.	Datum	Inhalt	Ort	Von Wem
0		Virtual Test Driving (VTD) CarMaker Quick Start Guide	T314 T318	Self-study
1	07.10.	Requirements for vehicles and their global attributes	T314 T318	Schick
3	14.10.	Vehicle dynamics attributes and their target conflicts	T314 T318	Schick
3	21.10.	Test and evaluation methods for vehicle attributes (1) with practical simulation	T314 T318	Schick
4	28.10.	Test and evaluation methods for vehicle attributes (2) with practical simulation	T314 T318	Schick
5	04.11.	Basic vehicle dynamics calculation and vehicle models with exercise	T314 T318	Böhle
6	11.11.	ADAS DRIVING EVENT Measurement Tech. Introductions PSA - Introduction	IFM	Günther/Riedlmüller/ Schwandke

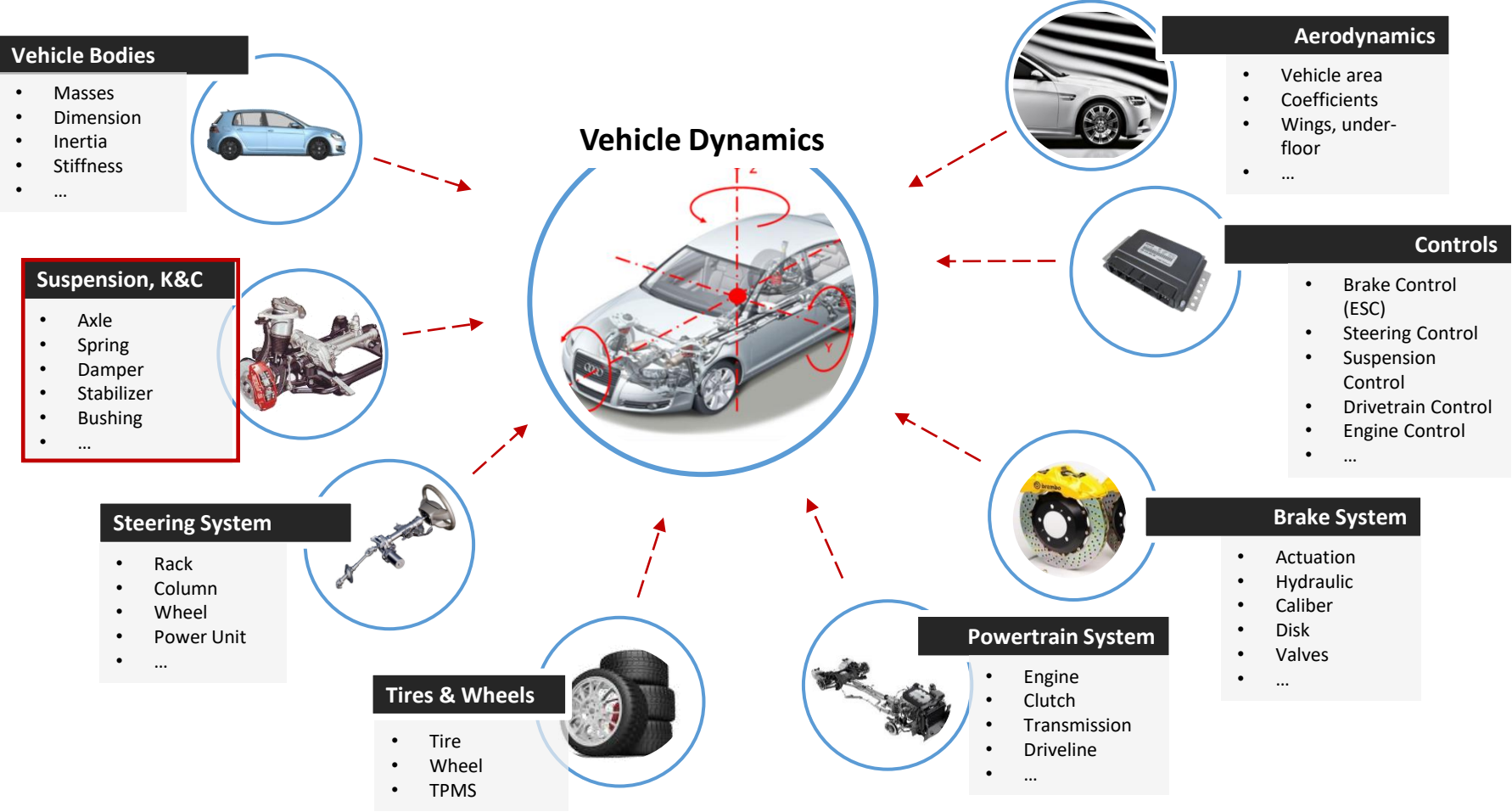
7	18.11.	Chassis components and functions (1) Tire & Wheels with practical simulation	T314 T318	Schick
8	25.11.	Chassis components and functions (2) Axle & Suspension w. practical simulation	T314 T318	Schick
9	02.12.	Chassis controls and functions (1) Overview & Brakes & Steering	T314 T318	Schick
10	09.12.	Chassis controls and functions (2) ESP-Functions & Application & Process	T314 T318	Albert Lutz (BOSCH)
11	16.12.	Chassis controls and functions (3) ESP-Application & Hands-On Workshop	T314 T318	Albert Lutz (BOSCH)
12	13.01.	Chassis controls and functions (4) ESP-Application & Hands-On Workshop	T314 T318	Albert Lutz (BOSCH)
13	20.01.	TEND: ADAS Development for a sports car manufacturer	T314 T318	Manuel Höfer (Porsche)

Chassis components and functions – axle & suspension

The chassis provides the link between the vehicle body and the tyres/road.



Vehicle dynamics behavior is impact by numerous components



Chassis components and functions – axle & suspension

Chassis is responsible for the interconnection between the vehicle - including passengers and luggage - and the road

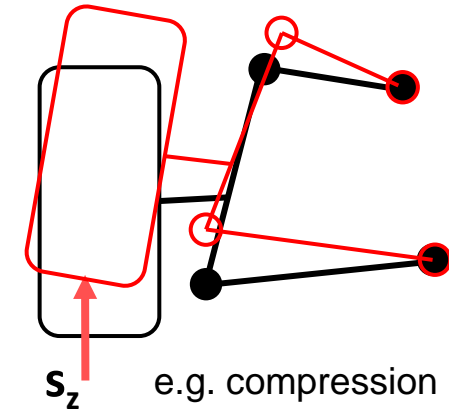


- Outer forces and moments are transferred via the tires via the suspension to the vehicle inner forces.
- The suspension is responsible to bring the tire into a optimal position for the force and moment transfer.

Important suspension characteristic behavior

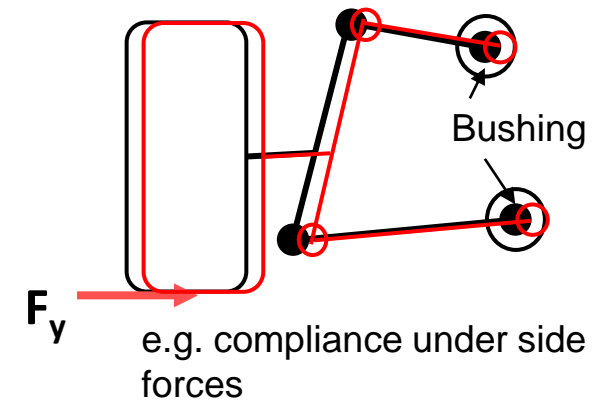
Kinematics

Description the change in the 3D wheel position which occur due to suspension compression, rebound and by steering movements.



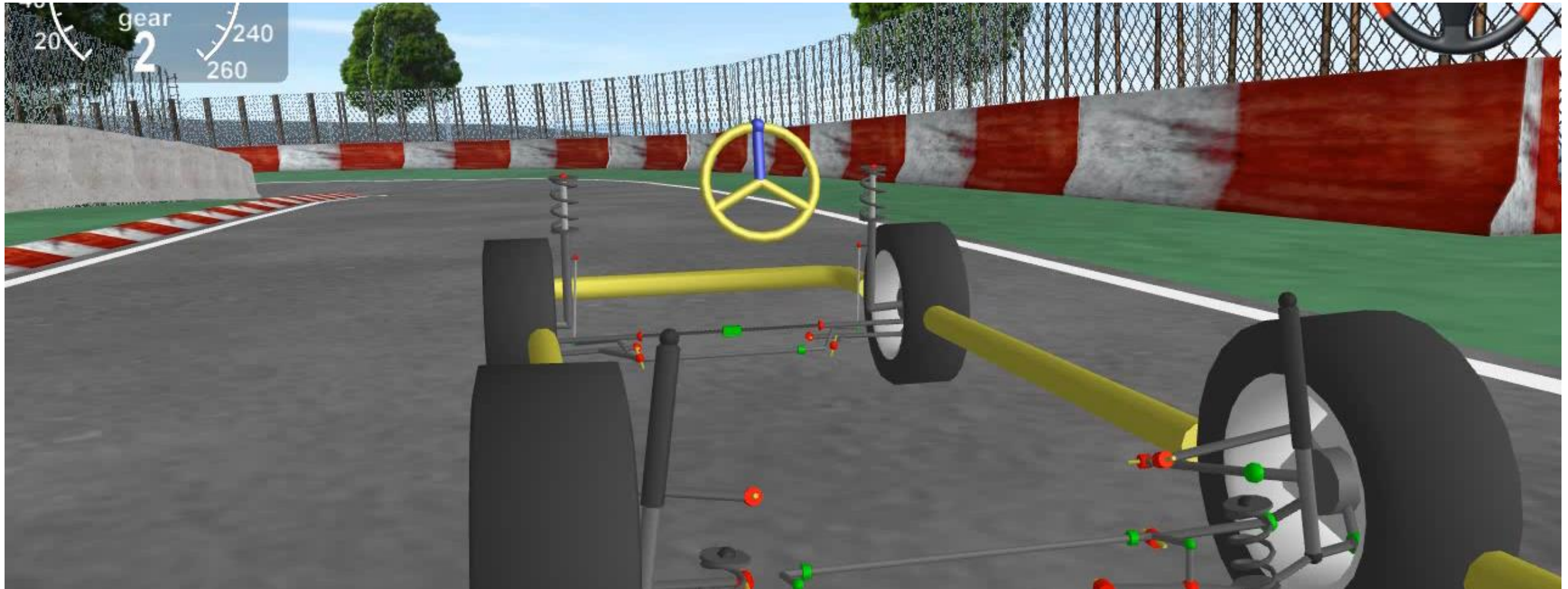
Compliance (elastokinematic)

Description the change in the 3D wheel position, which occur due to the forces and torques on the wheel / tire under targeted elastic interpretation of suspension parts.



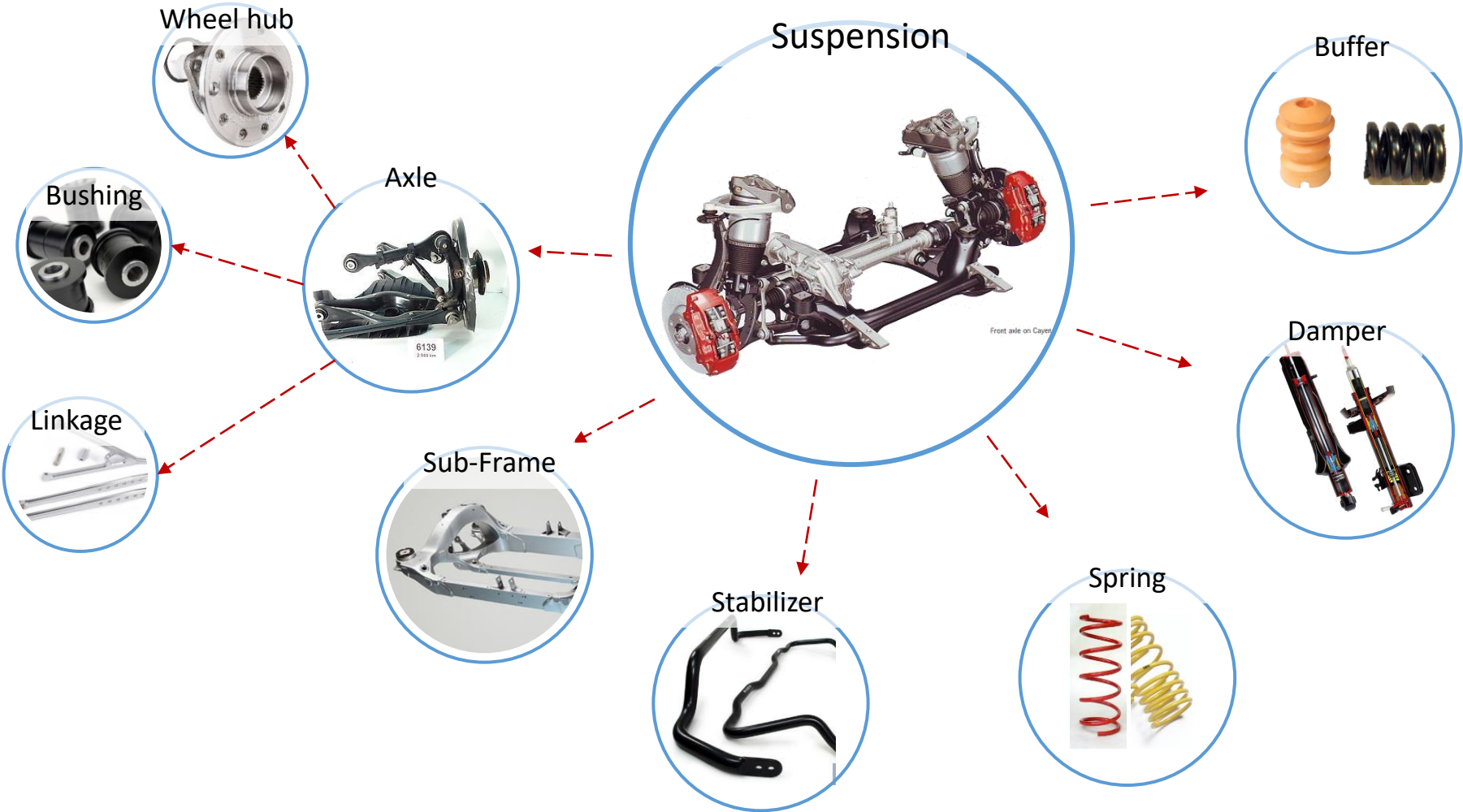
Chassis components and functions – axle & suspension

Axle, suspension, kinematics & compliance characteristics

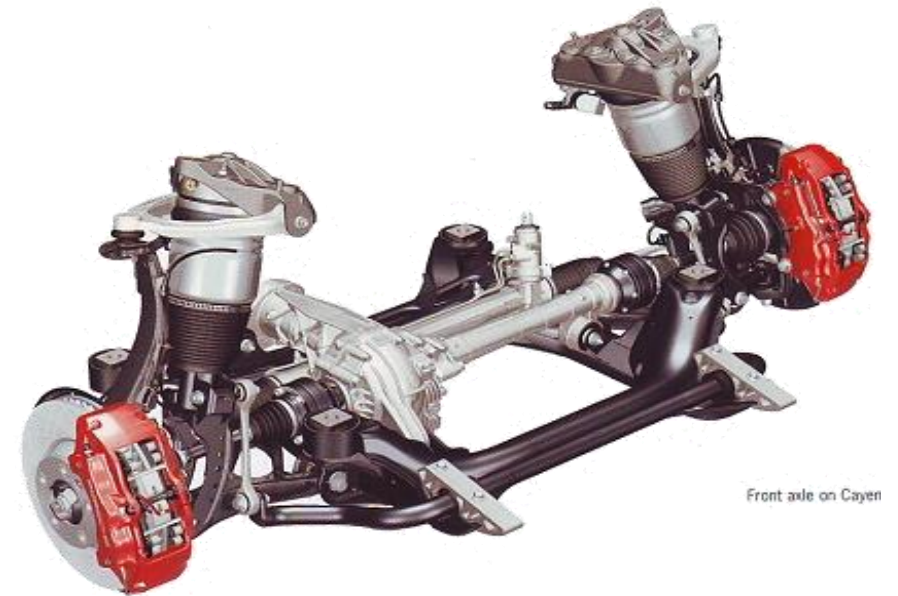
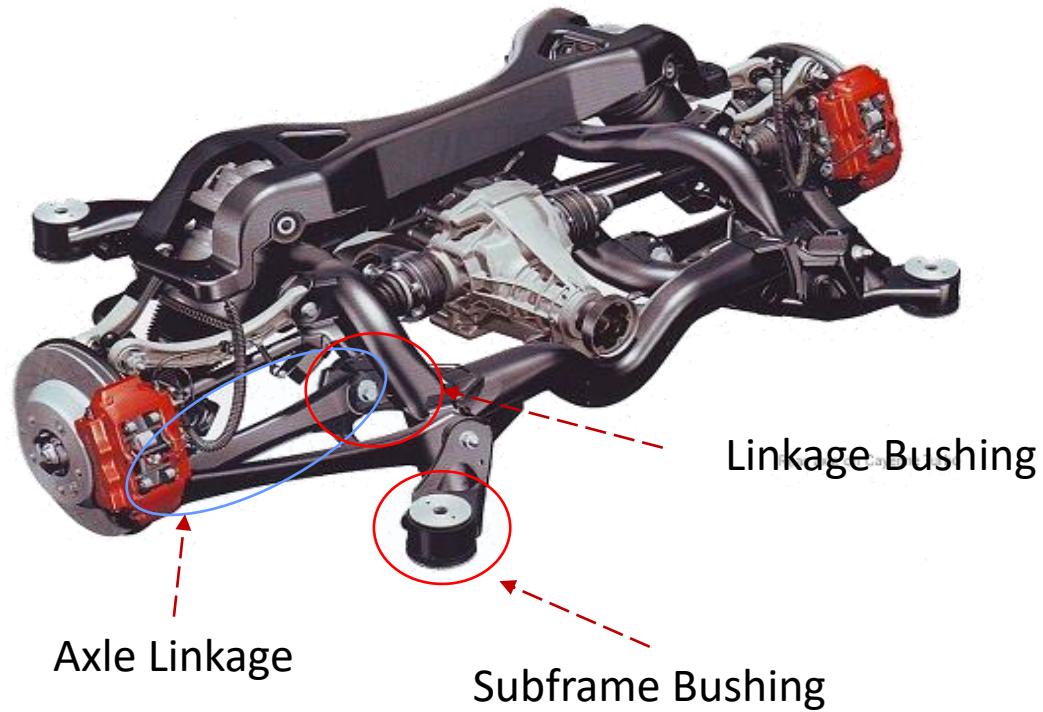


Chassis components and functions – axle & suspension

Suspension components



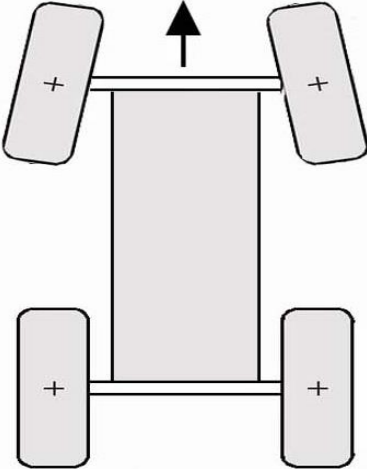
Suspension components



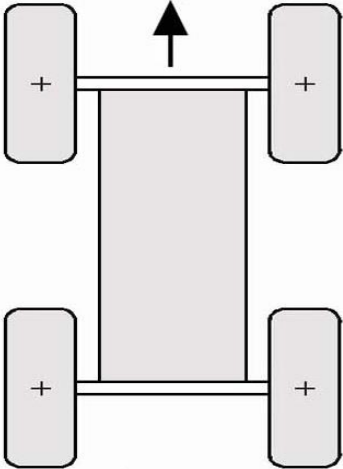
Chassis components and functions – axle & suspension

Static axle alignment

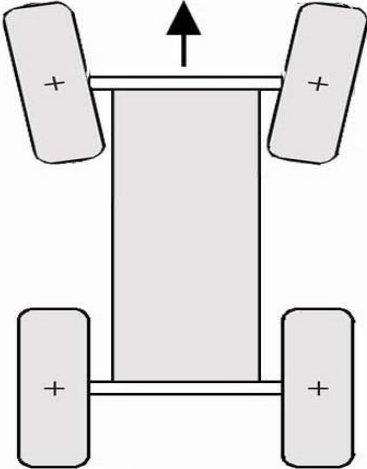
Toe-In



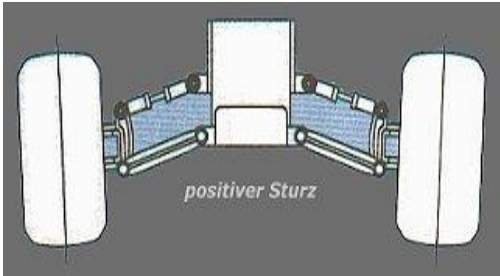
Toe-Zero



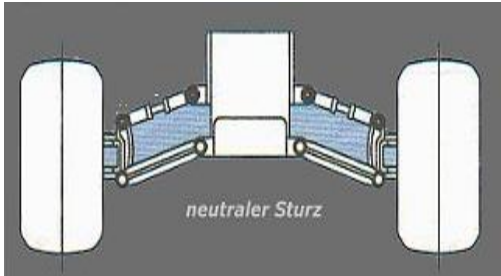
Toe-Out



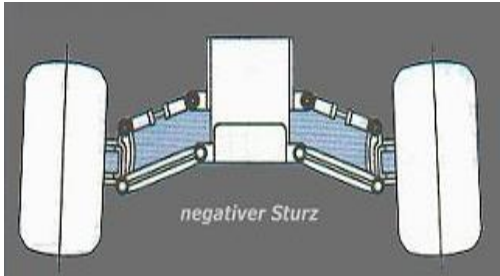
Camber positive



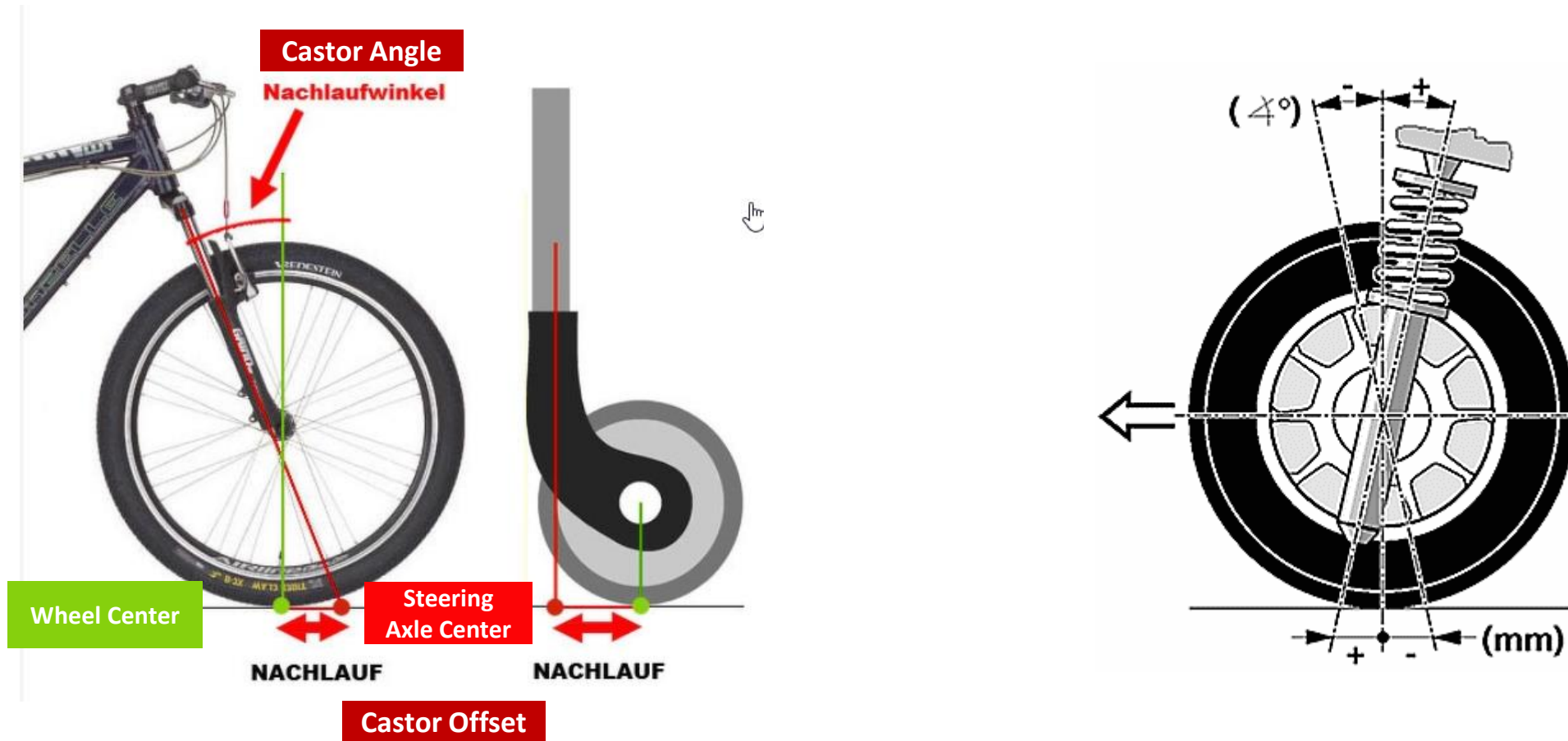
Camber zero



Camber negative

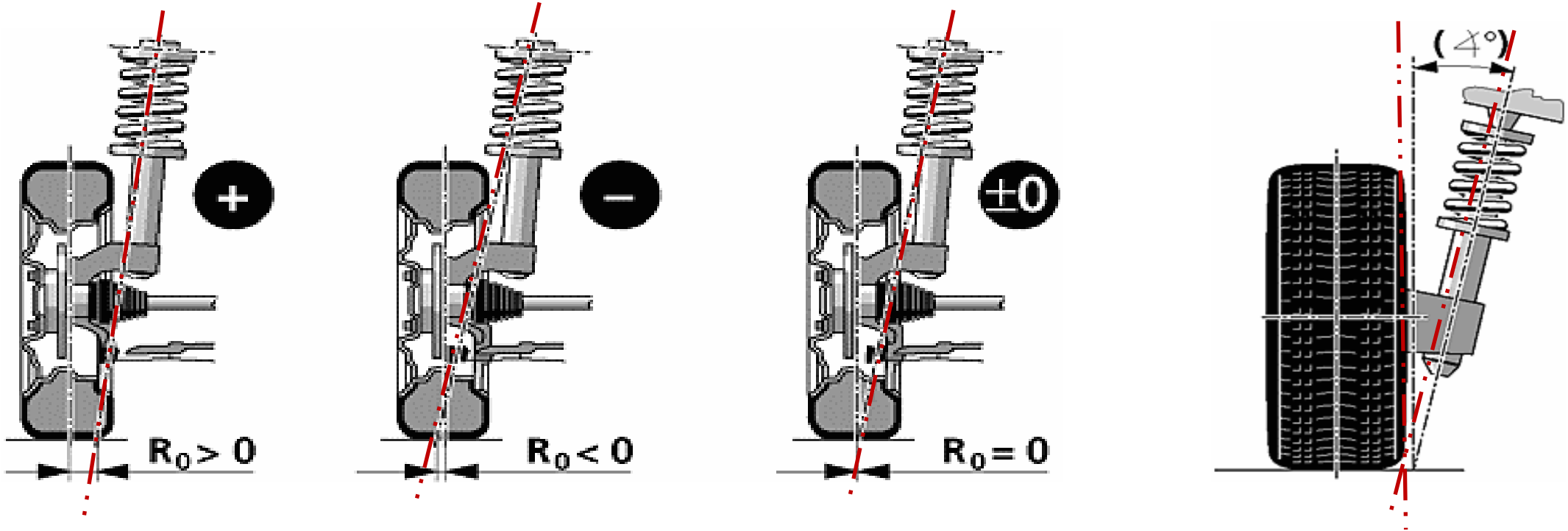


Important geometrical suspension characteristic values



→ Bigger caster leads more wheel stability but higher steering torque.

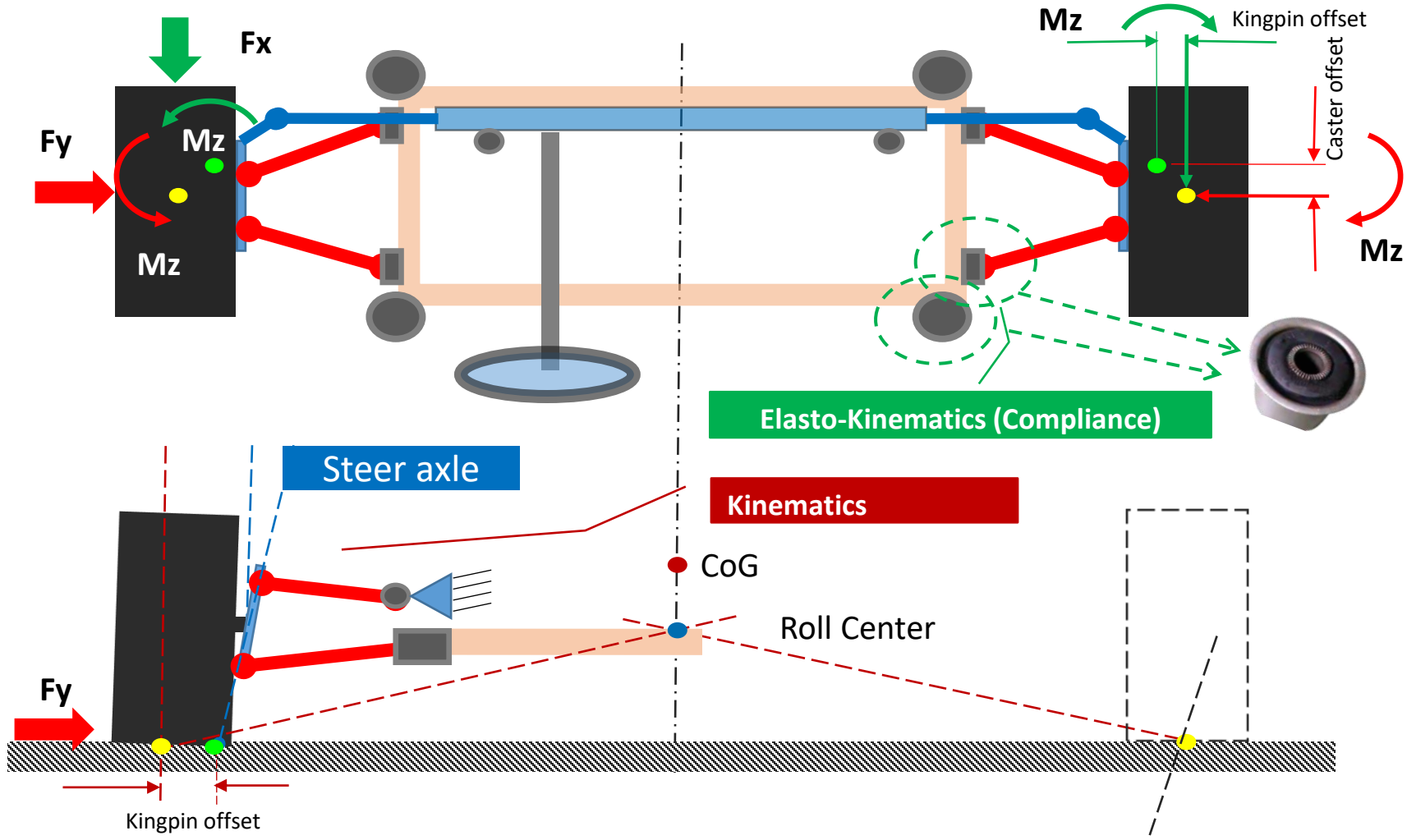
Important geometrical suspension characteristic values



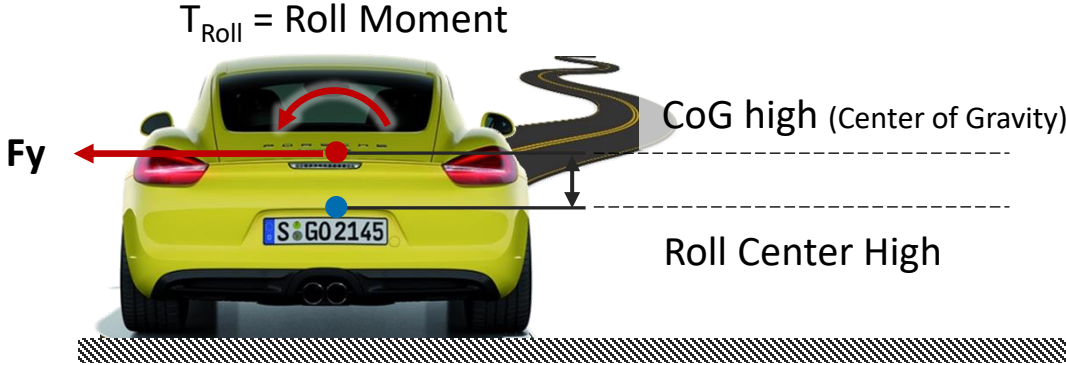
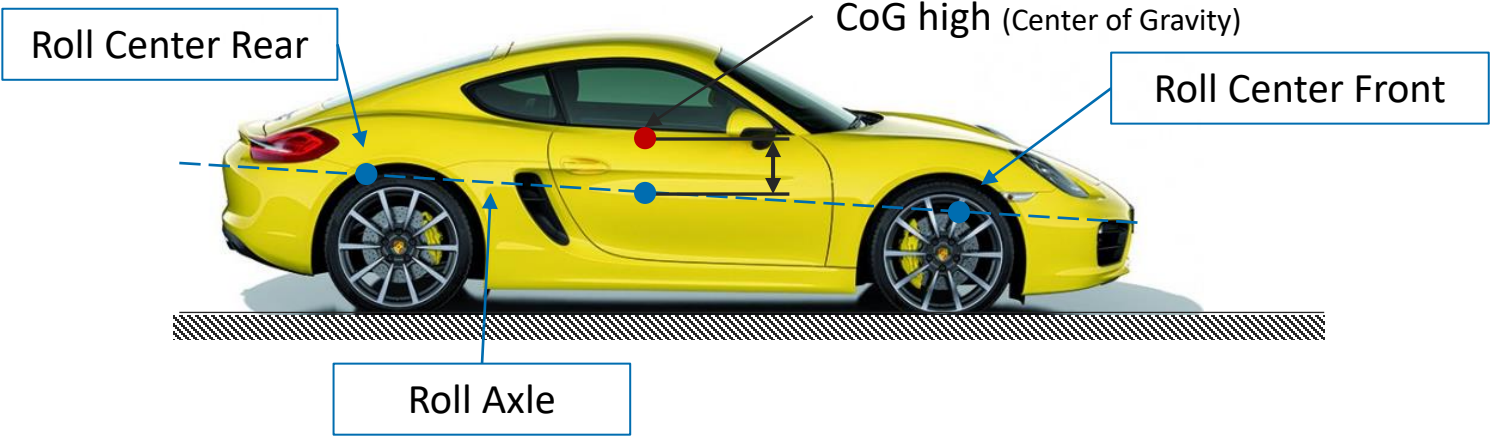
King-Ping Offset (Lenkrollhalbmesser)

King-Ping Inclination

Important geometrical suspension characteristic values



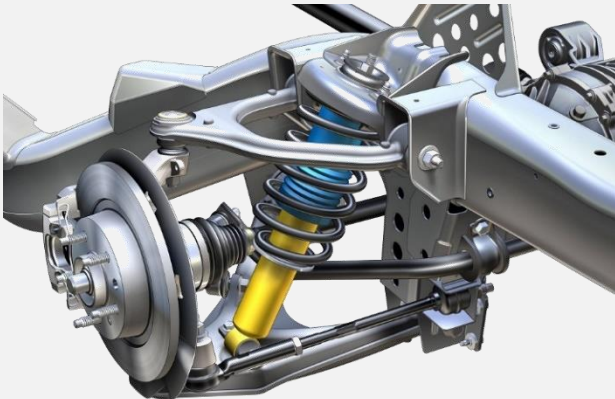
Important geometrical suspension characteristic values



Suspension types

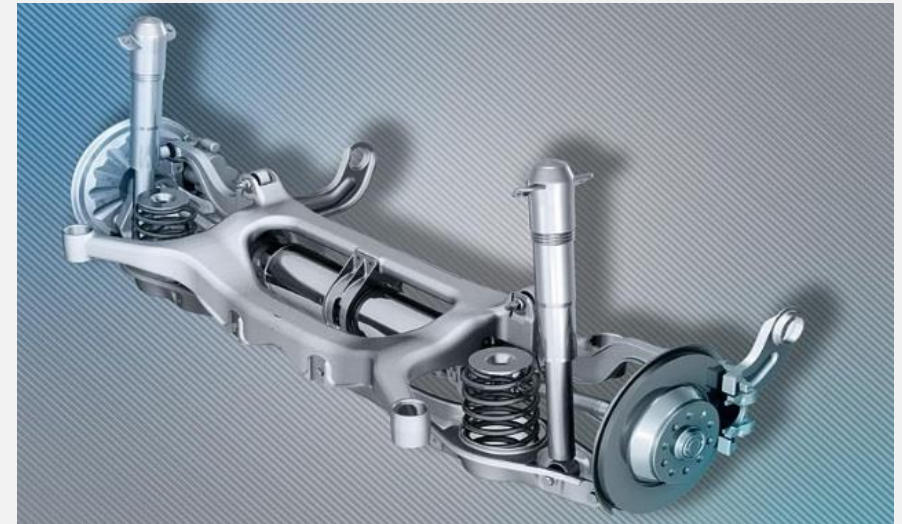
Front Suspension

- McPherson Axle
- Double Wishbone Axle
- Rigid axle
- Strut Axle
- ...



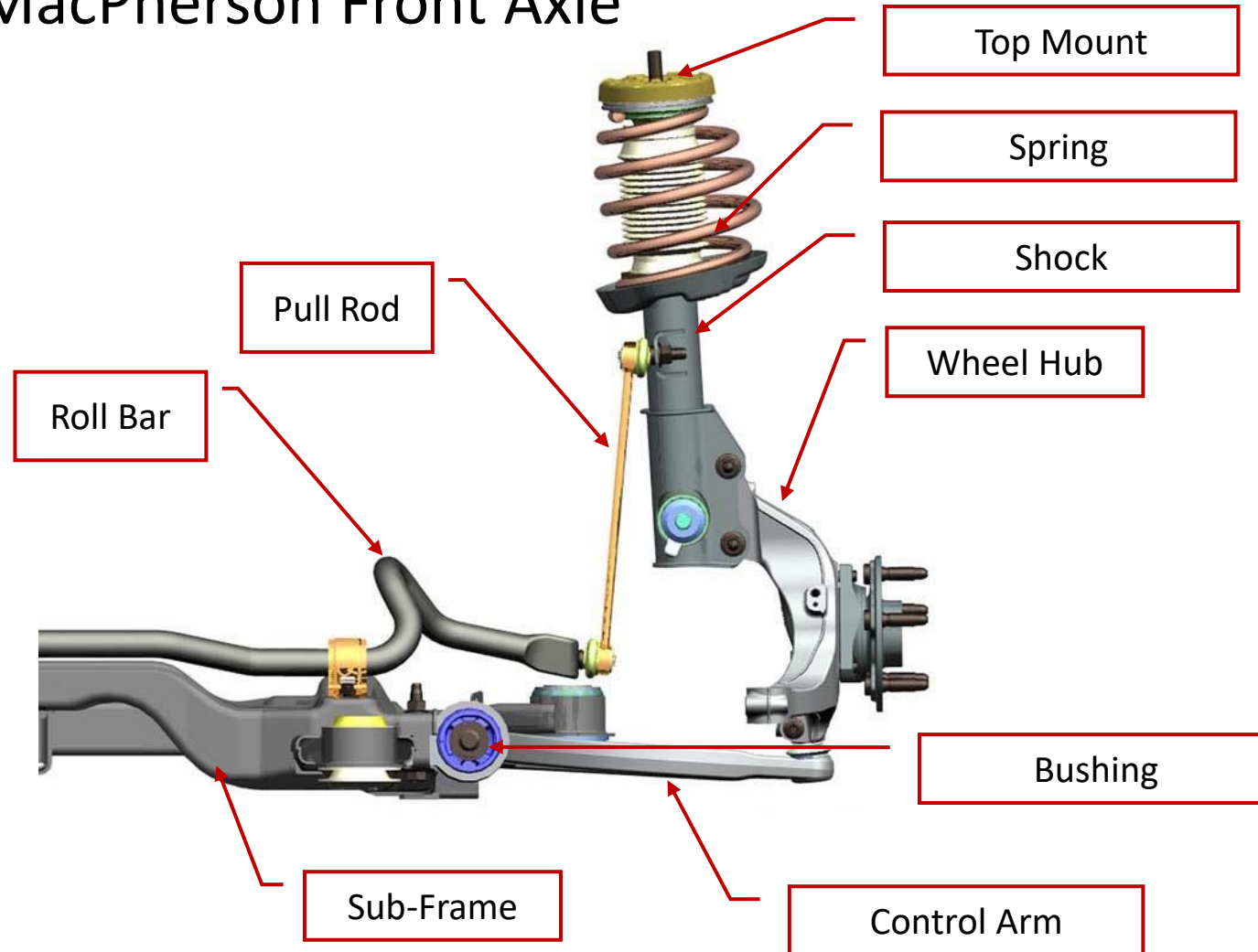
Rear Suspension

- Rigid axle
- Twist Beam Axle
- Double Wishbone Axle
- 4-Linkage Axle
- Multi-Linkage Axle
- Sword Linkage Axle
- Strut Axle
- Longitudinal Linkage Axle
- Semi Trailing Arm Axle
- ...



Chassis components and functions – axle & suspension

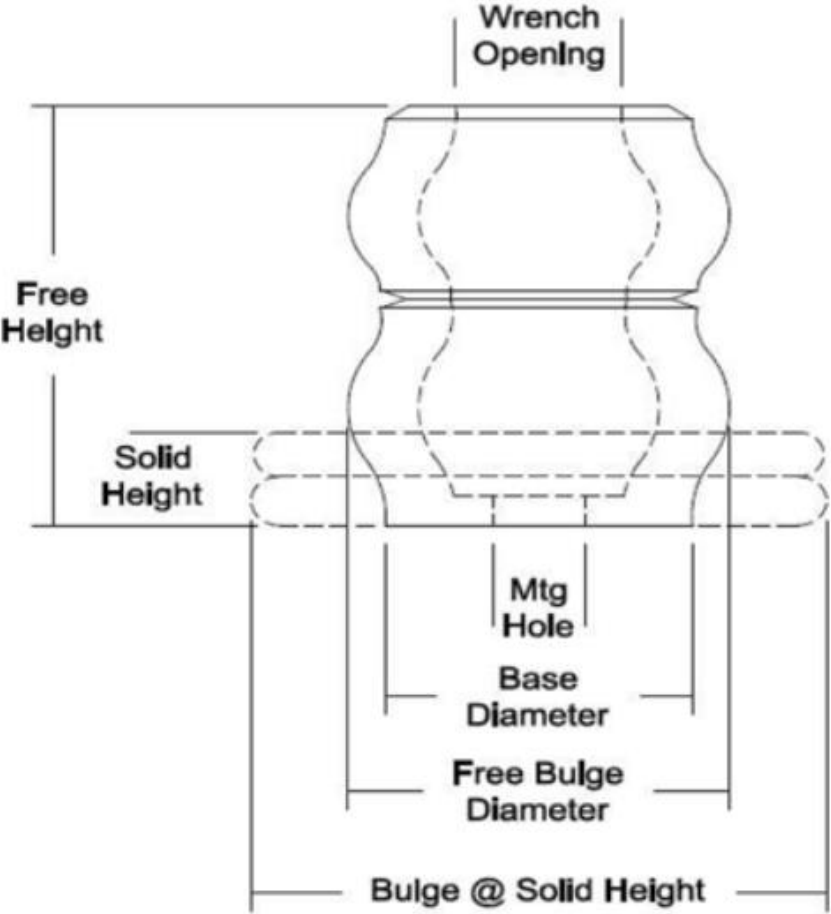
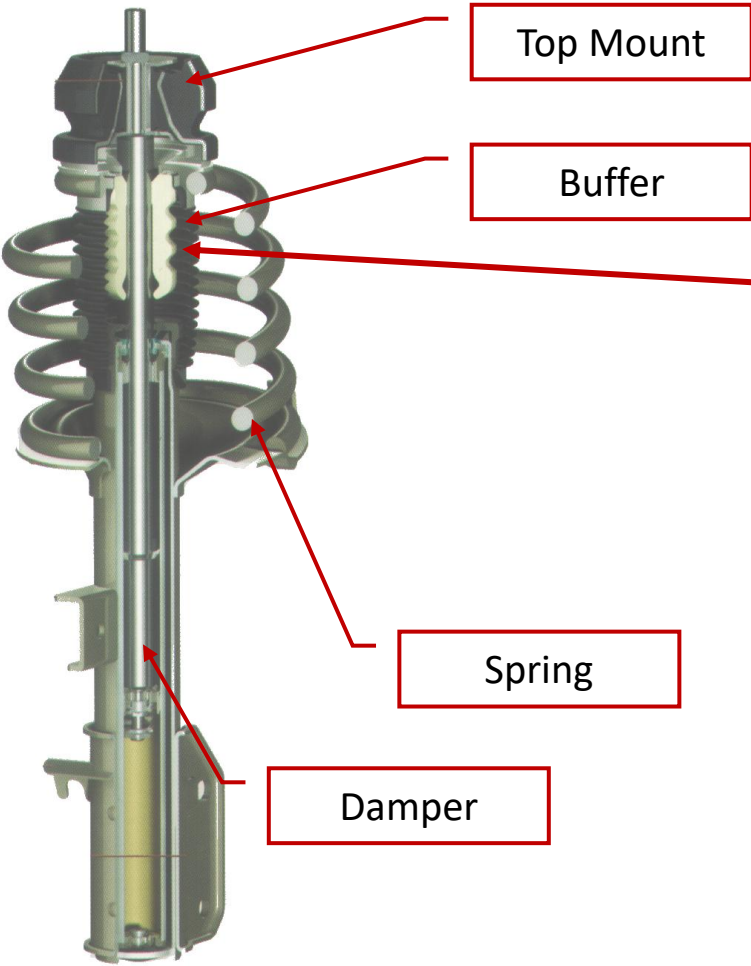
Suspension types: MacPherson Front Axle



Bushing for force reactive wheel position and isolation

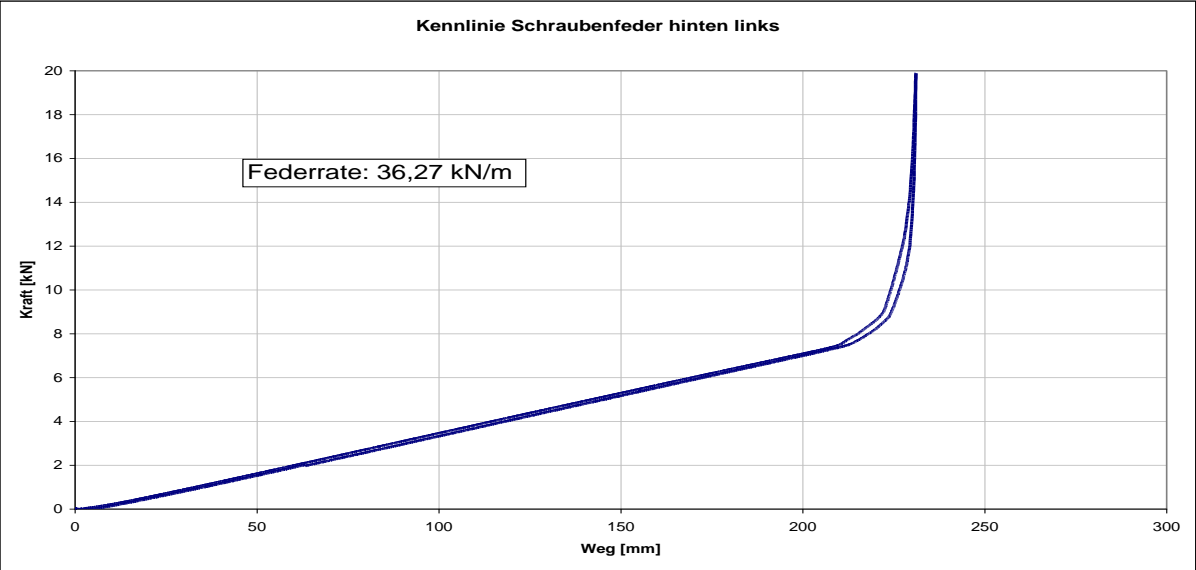


Bumper the additional spring

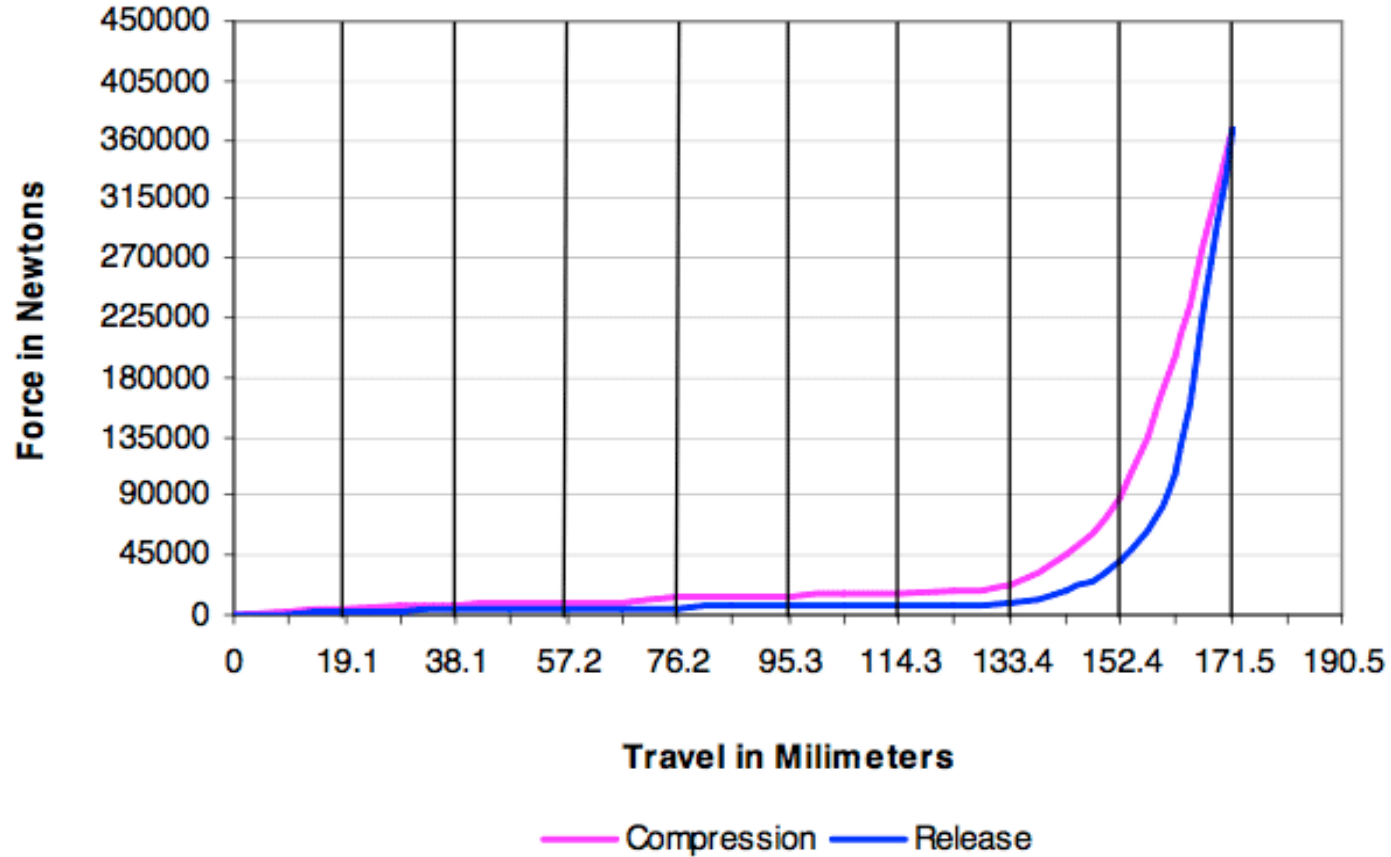


Chassis components and functions – axle & suspension

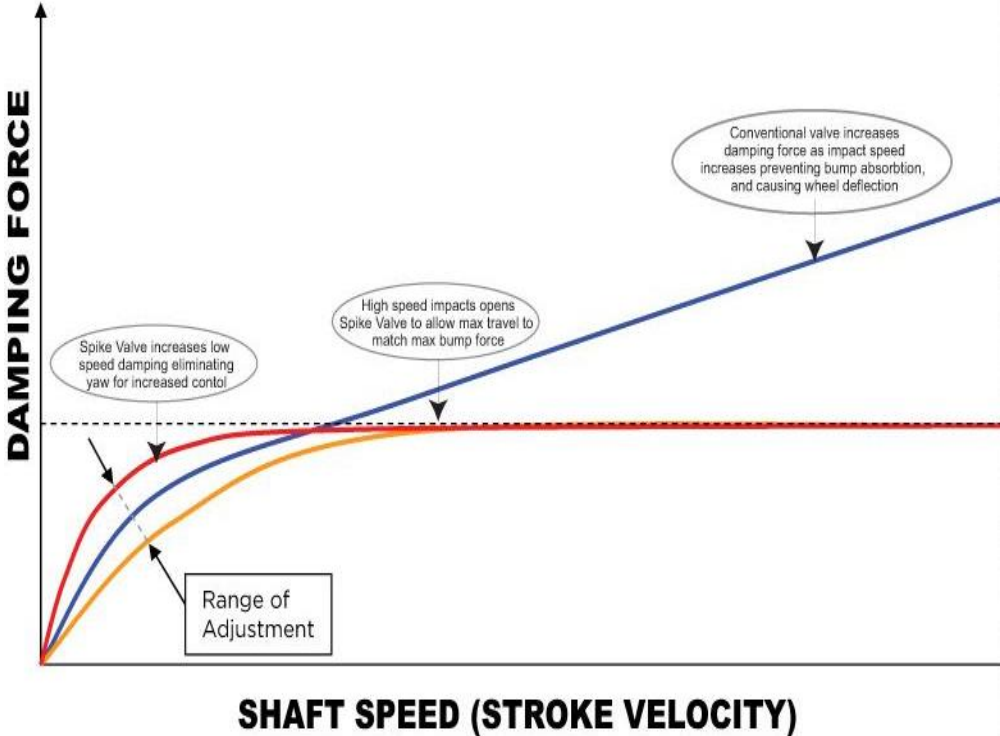
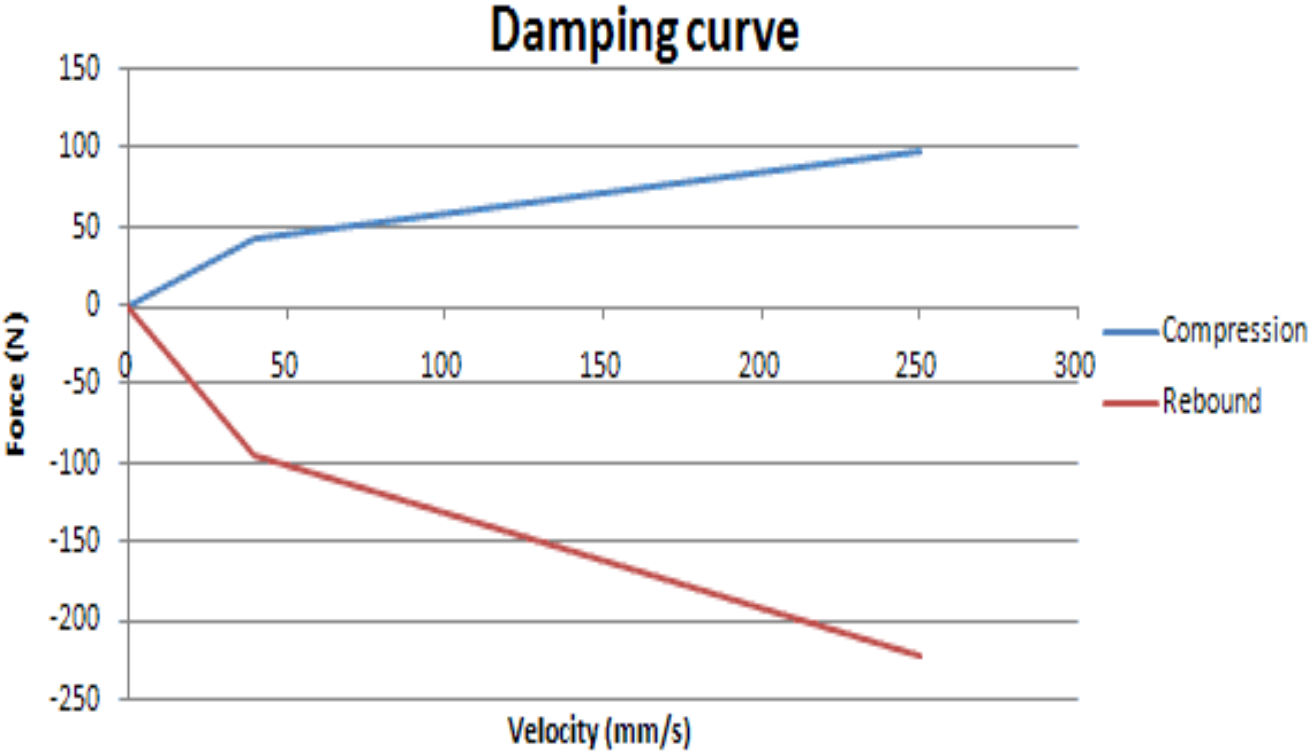
Spring & Damper & Buffer



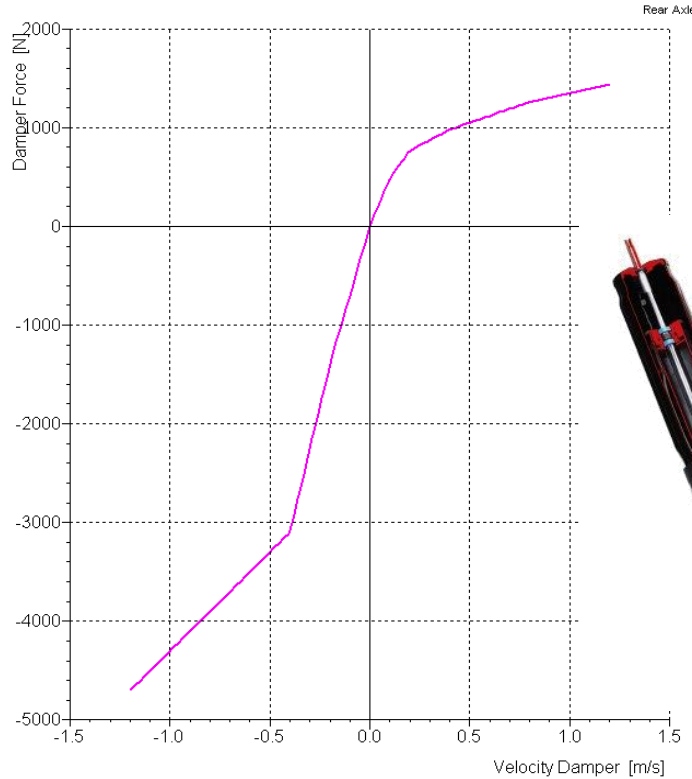
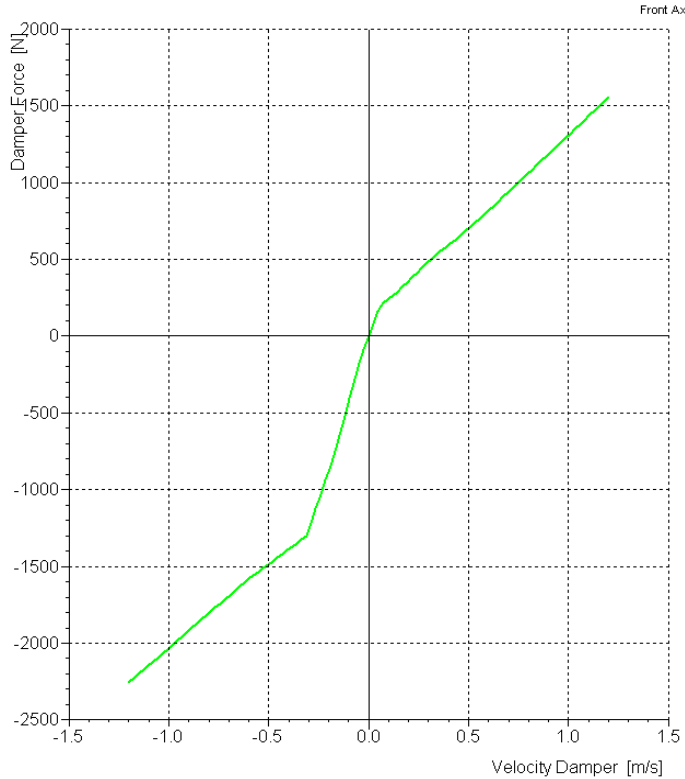
Bumper the additional spring



Damping curve and measurement



Damping curve and measurement

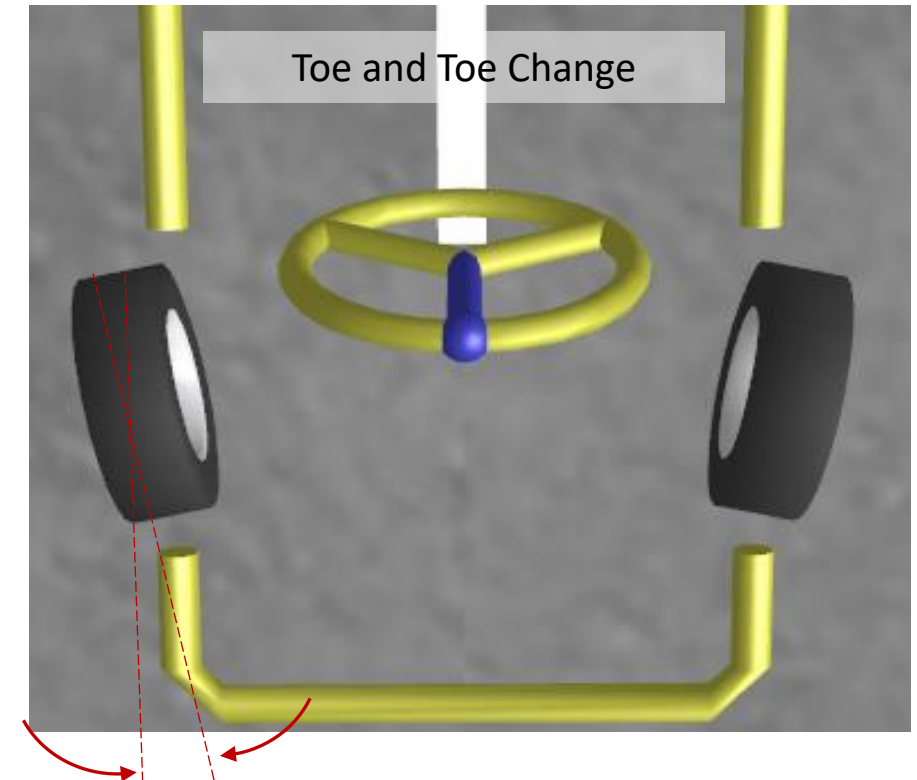
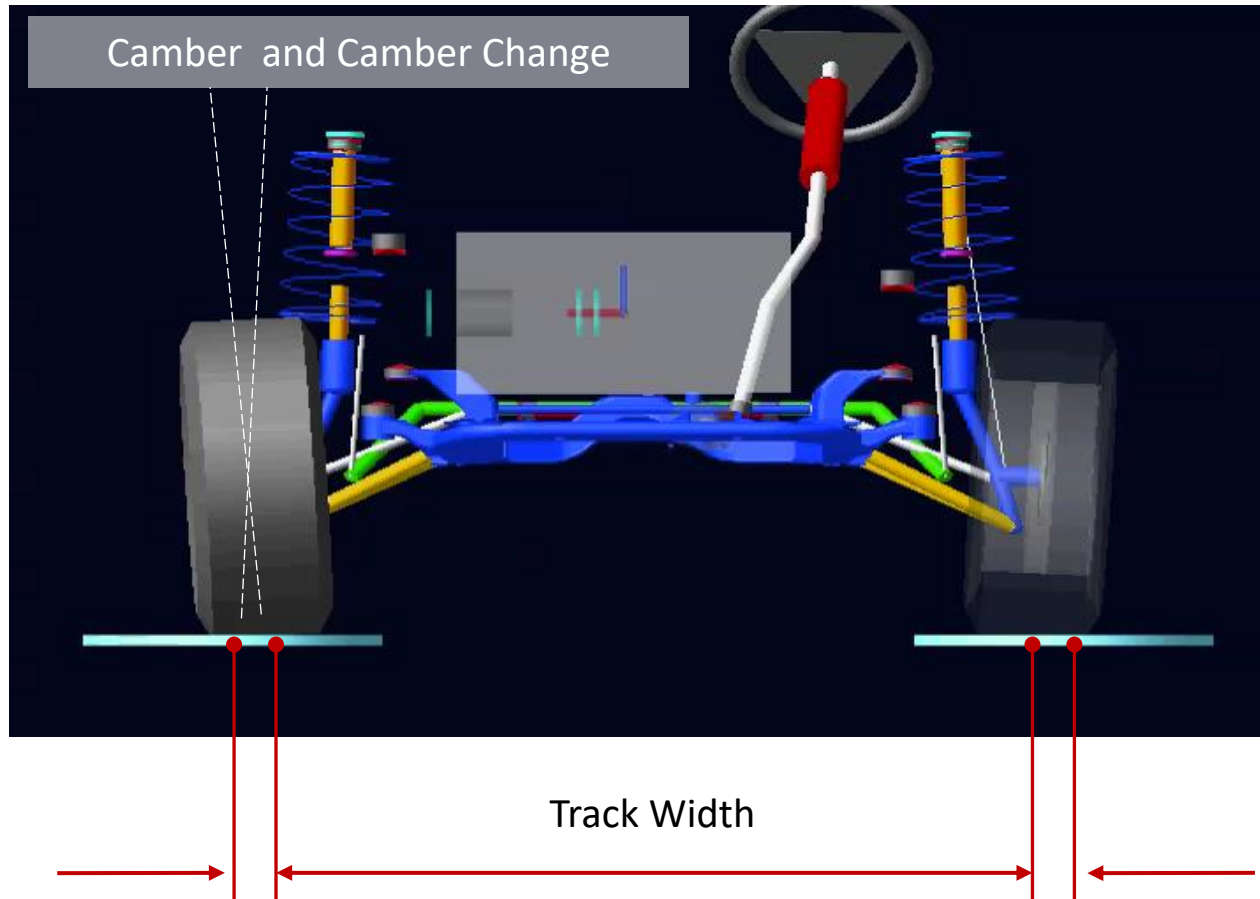


Damper Characteristic: positive velocity for pull, negative for push
 — front left — front right — rear left — rear right
 Vehicle: 'DemoCar'

CarMaker 3.0pre11 Model Check	Damper Forces (component related)	
----------------------------------	-----------------------------------	--

Thu, 09/07/2009, 21:50:24 Vlies-Innung-Beitrag: Komatzell, Page 3

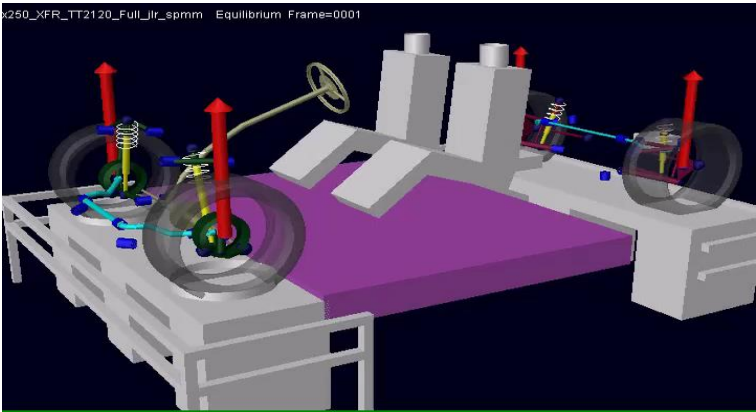
K&C (kinematic & compliance) behavior



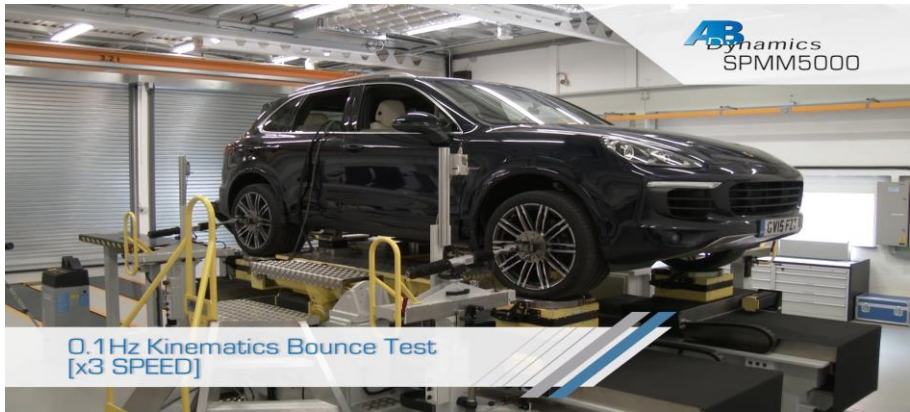
Chassis components and functions – axle & suspension

Virtual and real K&C test benches in a modern development

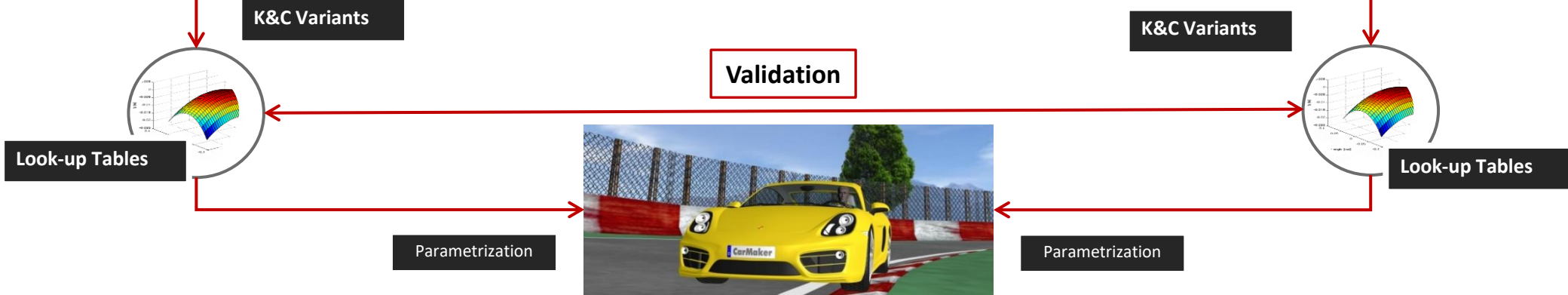
Virtual K&C Test Bench
MBS-Model



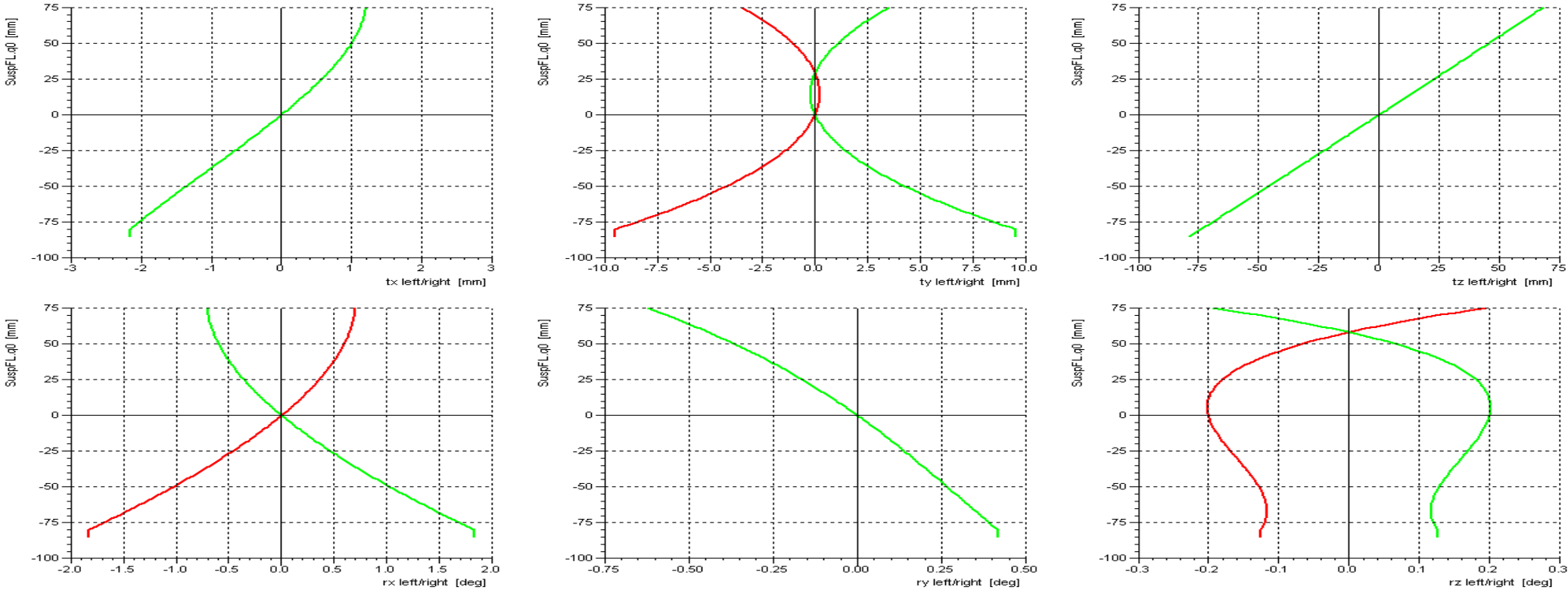
Real K&C Test Bench
Sample ABD SPMM 5000



- Bounce Test
- Roll Test
- Steer Test
- Side Force Test
- Accel. & Brake Test



Suspension – Kinematics & Compliance

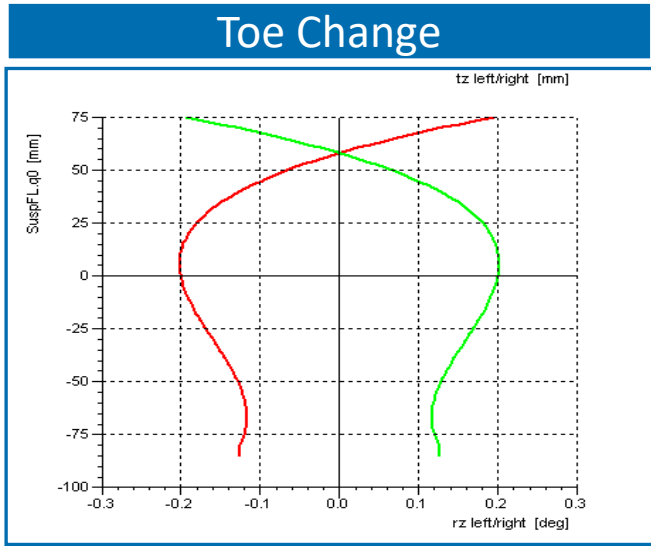
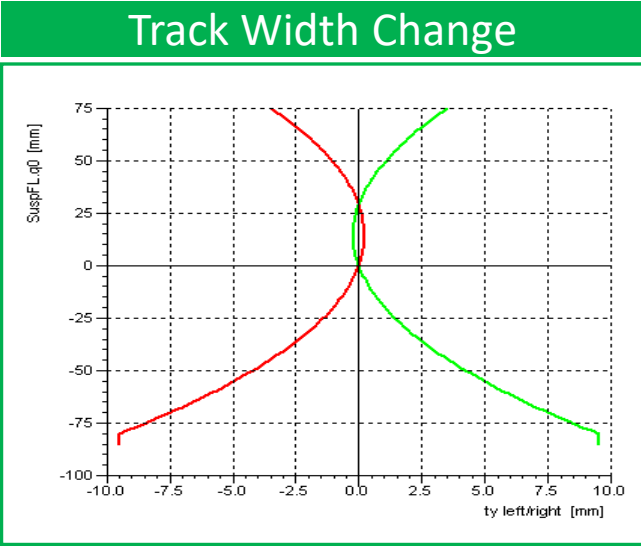
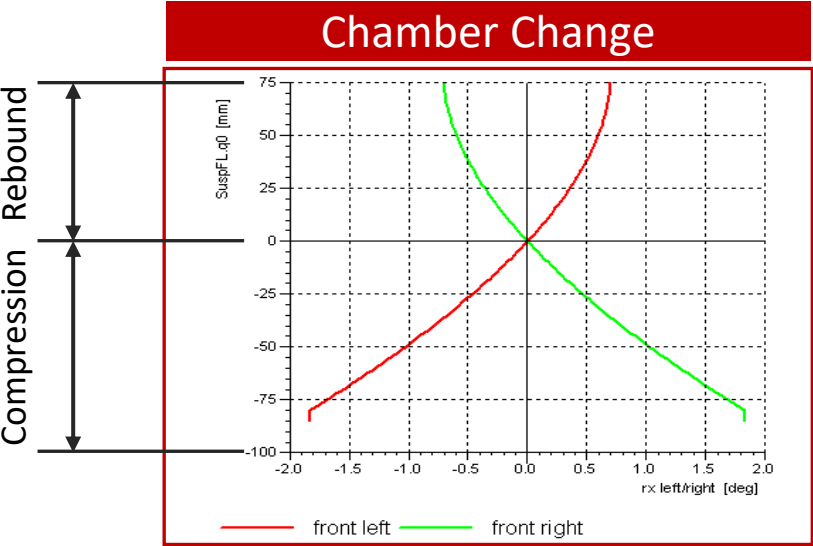


— front left — front right
 Front Suspension: /
 Vehicle: 'DemoCar'

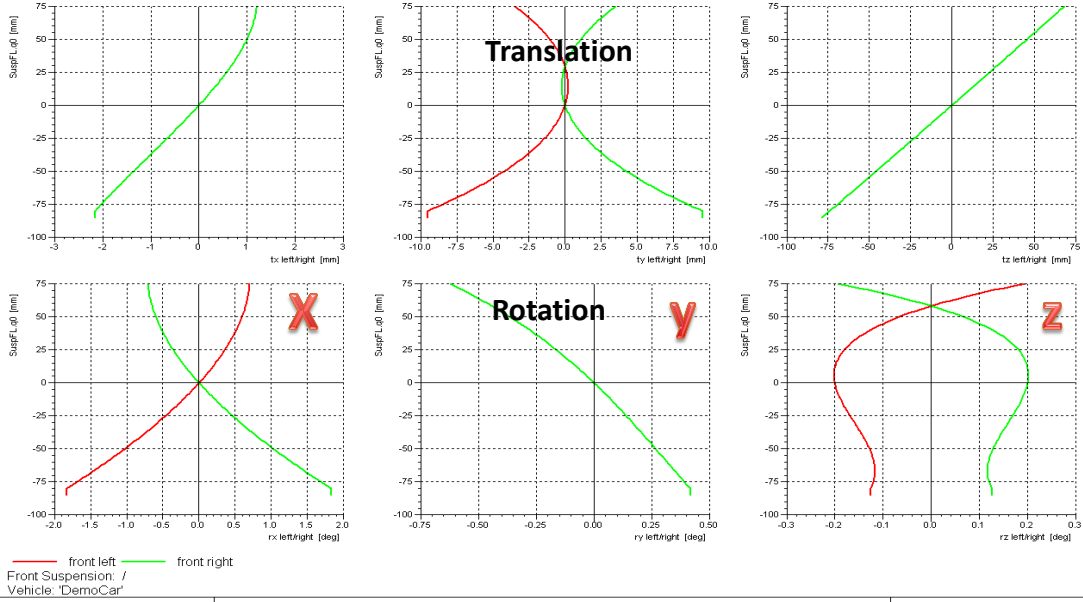
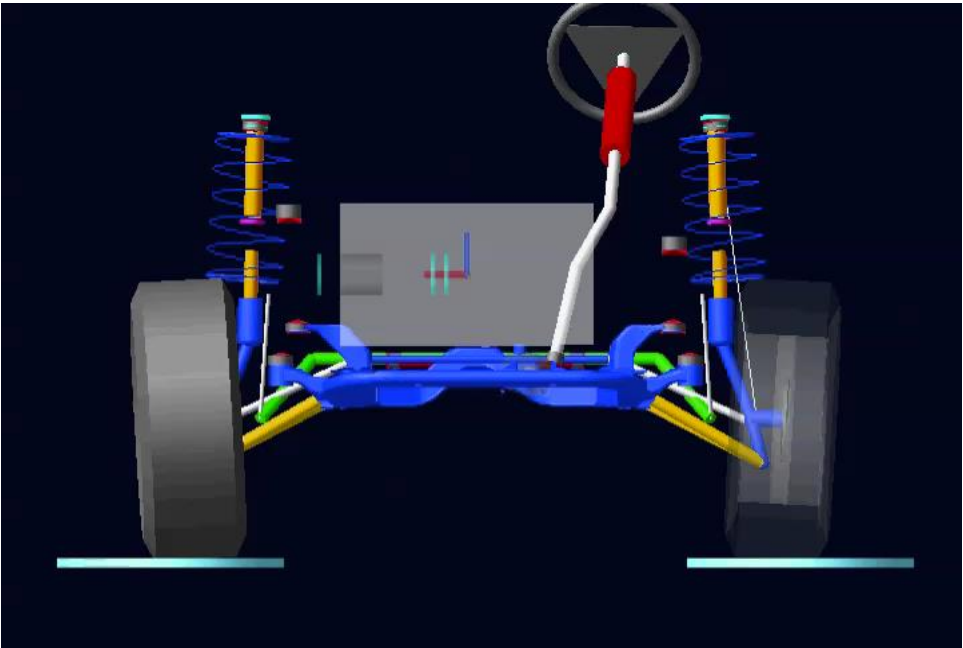
<p>CarMaker 3.0pre11 Model Check</p>	<p>Kinematics & Compliance: Parallel Compression Kinematics</p>	
--	---	--

Thu, 25-06-2009, 16:27:34 Westeuropäische Normalzeit, Page 1

Suspension – Kinematics & Compliance

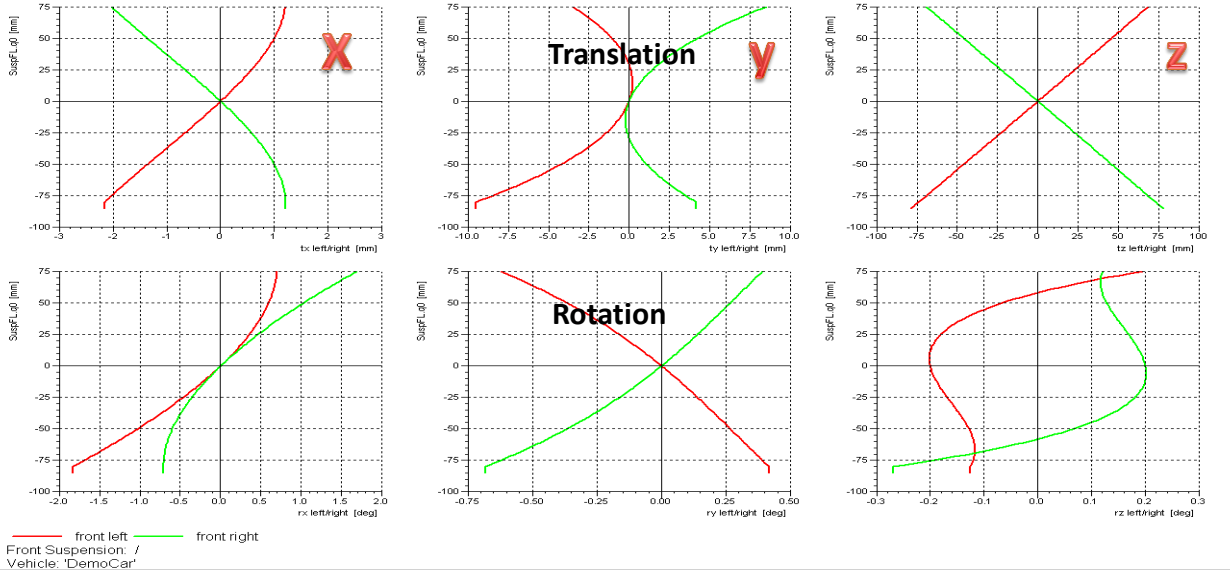
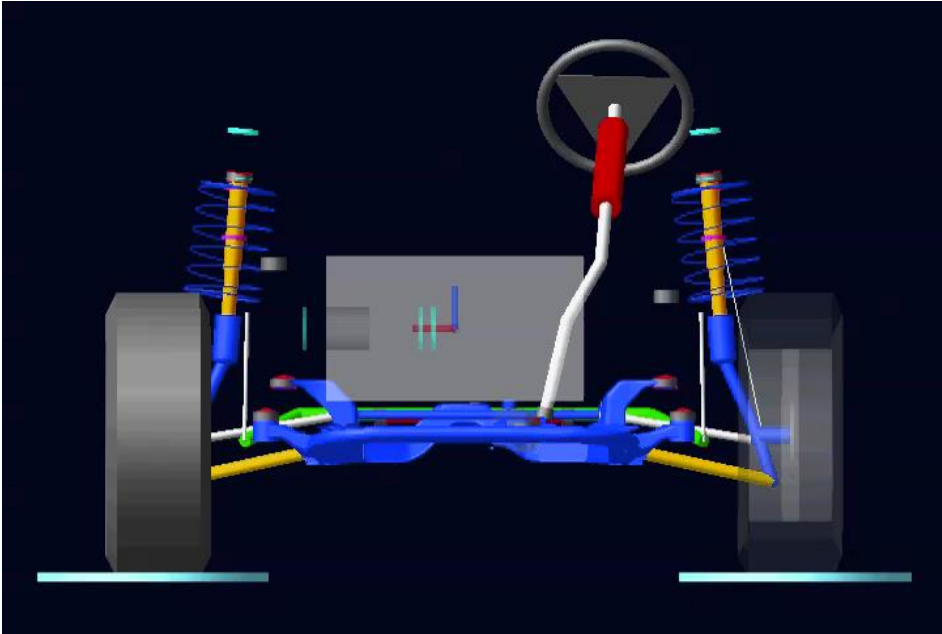


Kinematics & Compliance – Stroke or Bounce Test



CarMaker 3.0pre11 Model Check	Kinematics & Compliance: Parallel Compression Kinematics	The: 20060309_162031_vtk_kump/Michele_Remondelli Page 1
----------------------------------	--	---

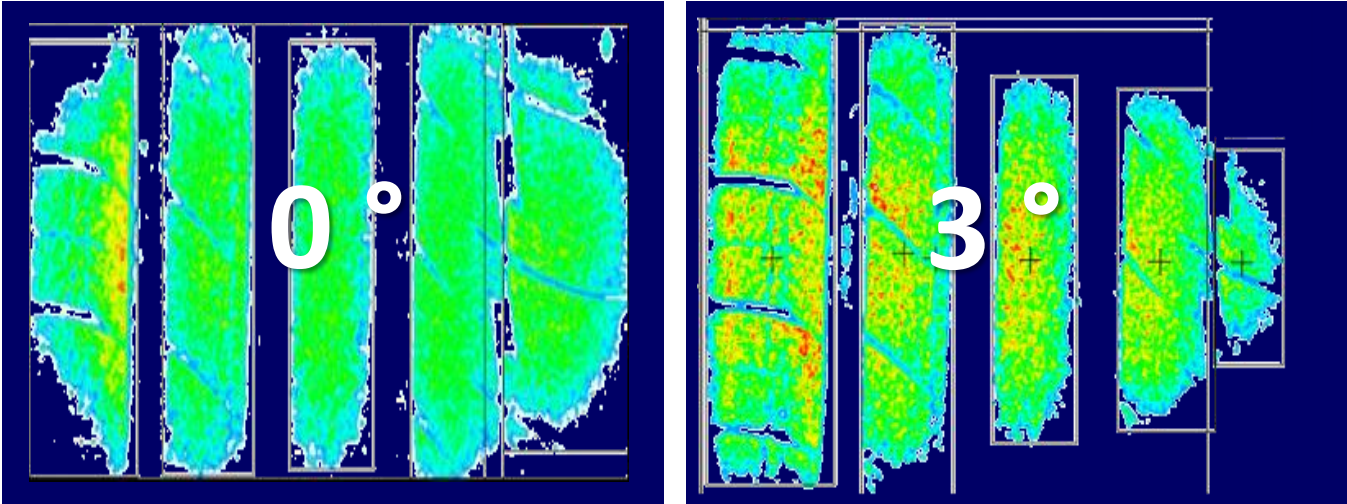
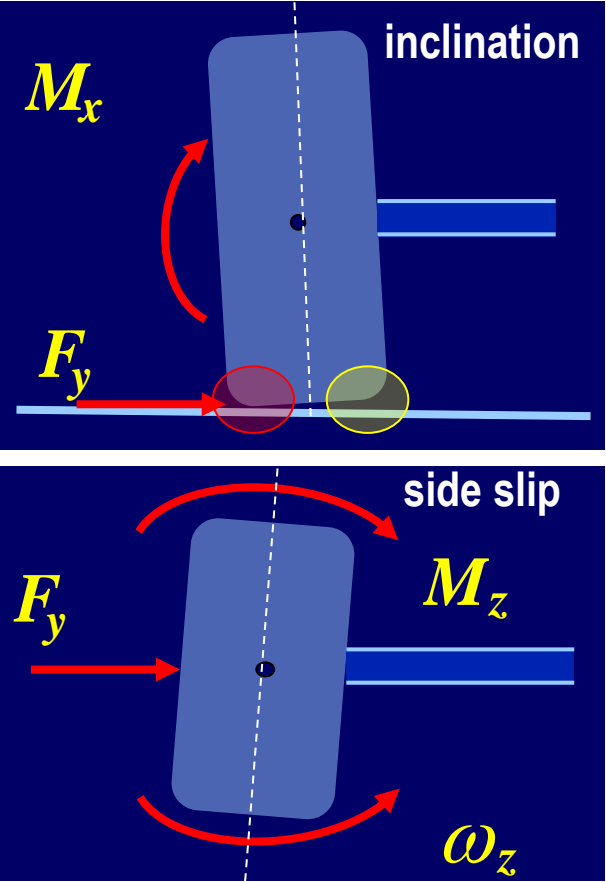
Kinematics & Compliance - Roll Test



CarMaker 3.0pre11 Model Check Kinematics & Compliance: Antiparallel Compression Kinematics

Thu, 26/06/2008, 16:27:24 View Group Anticlock Kinematics Page 2

Suspension – Kinematics & Compliance

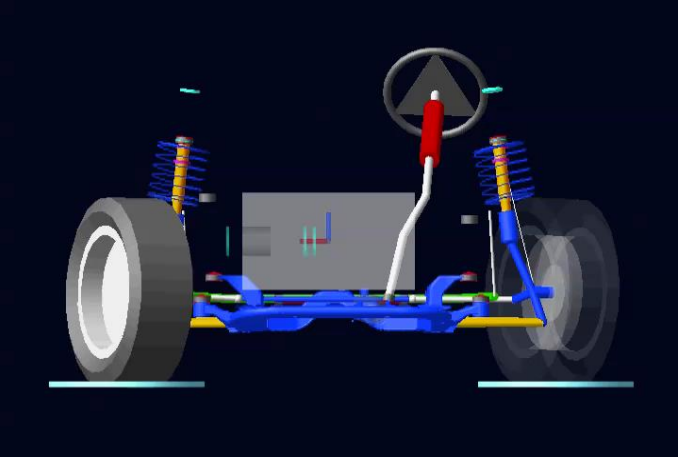


Vehicle Dynamics Rule No. 2:

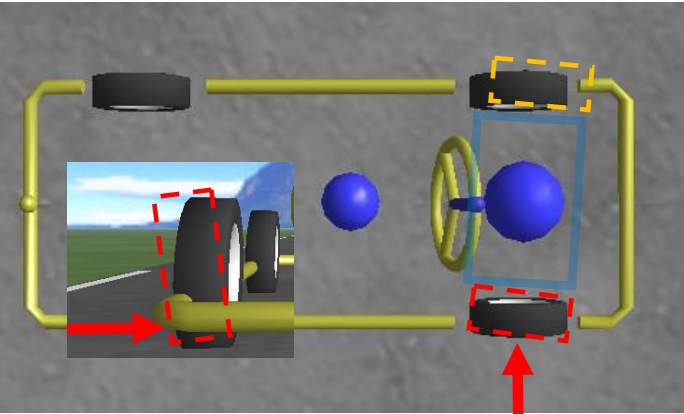
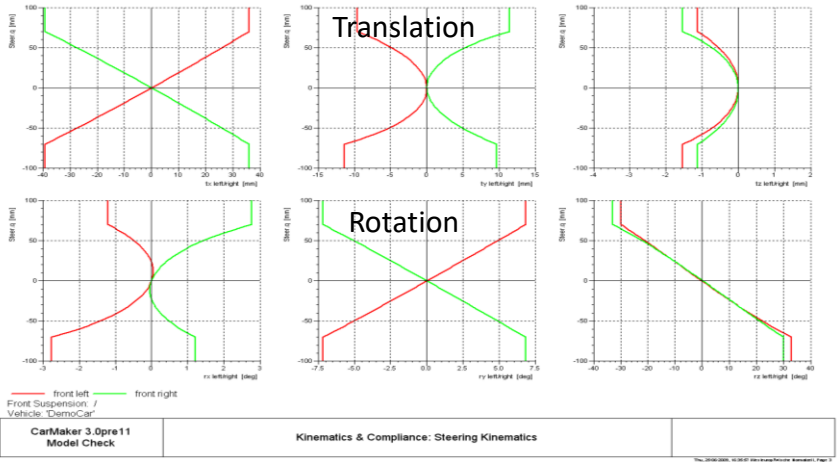
Produce a harmonic foot print

Chassis components and functions – axle & suspension

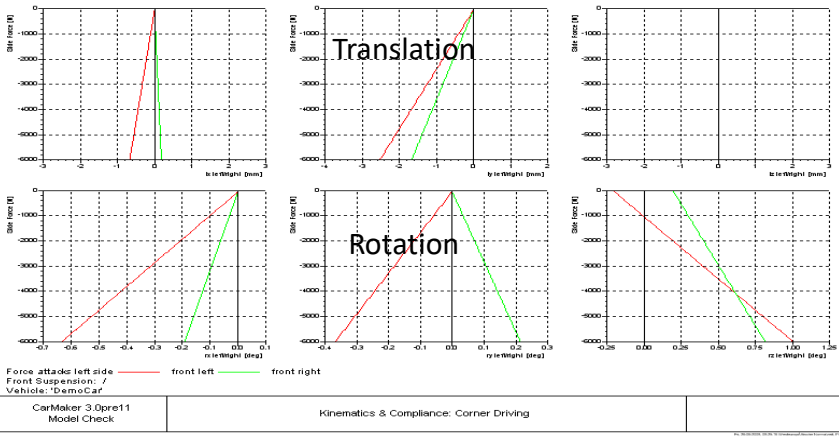
Suspension – Kinematics & Compliance



Steer Test



Side Force Test



Parameter Study for K&C, spring, damper, roll bar

Steady Circular Driving

1

Test Condition

Constant Radius: 100 m
Speed: 0 – max kph
 da_y : 0,1 m/s²/s
SWA, a_y , Yaw, Radius: steady state condition

Analysis Steady Circular Driving

Find the sensitivity of parameters such as

- Roll bar stiffness ✓
- Spring, buffer
- Toe change front / rear (K&C)
- Camber change front / rear (K&C)
- ...

Sine Sweep

2

Test Condition

Speed: 80 kph
Steer Input: Sine 0.2 – 4 Hz
 a_y : 0.4 g

Analysis Sine Sweep

Find the sensitivity of parameters such as

- Mass/Mass distribution / inertia
- Roll bar stiffness
- Damper
- Tire side slip stiffness
- ...

Linear 2DOF kinematic model (bounce & steer) parameter

CarMaker - Vehicle Data Set: Compact.car

Vehicle Data Set

Vehicle Body | Bodies | Engine | Suspensions | Steering | Tires | Brake | Powertrain | Aerodynamics | Sensors | Misc.

Spring

Secondary Spring

Damper

Buffer

Stabilizer

Kinematics

Compliance

Wheel Bearing

External Forces

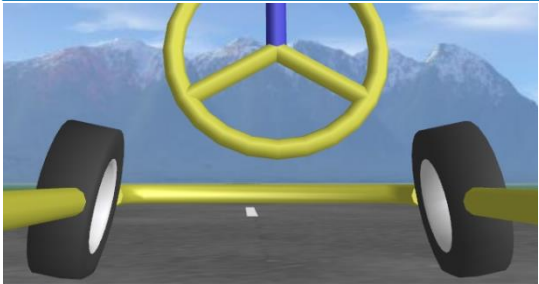
Front | Rear

Model: Linear 2 DOF

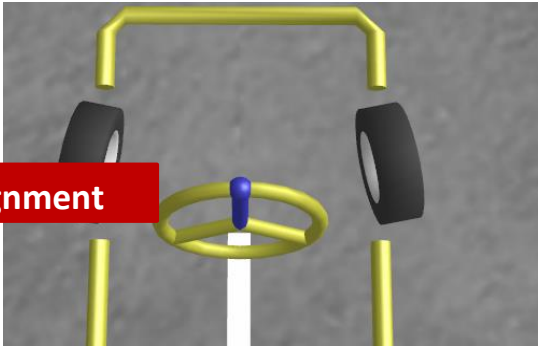
	Static	Compr.	Oppos.	Steer
Translation tx	0.0	0.023	0.0	-0.3
Translation ty	0.0	-0.007	0.0	-0.018
Translation tz	0.0	1.0	0.0	-0.033
Rotation rx	0.013	0.241	0.0	-0.473
Rotation ry	0.0	-0.05	0.0	-1.293
Rotation rz	-0.0	0.131	0.0	0.0
Deflection ISpring	0.0	-1.0	0.0	0.0
Deflection IDamp	0.0	-1.0	0.0	0.0
Deflection IBuf	0.0	-1.0	0.0	0.0
Deflection IStabi	0.0	1.0	0.0	0.0

Static Camber of axle alignment

Camber In (stroke)



Toe In (stroke)



Static Toe of axle alignment

Chassis components and functions – axle & suspension

Linear compliance model parameters

The screenshot shows the 'Vehicle Data Set' window in CarMaker. The 'Suspensions' tab is active, and the 'Compliance' sub-tab is selected. The model is 'Linear Frame Fr1'. The parameters table is as follows:

		dtx	dty	dtz	drx	dry	drz
Force X	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Force Y	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Force Z	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Torque X	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0
Torque Y	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0
Torque Z	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0
Force opposite X	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Force opposite Y	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Force opposite Z	[m/N]	0.0	0.0	0.0	0.0	0.0	0.0
Torque opposite X	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0
Torque opposite Y	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0
Torque opposite Z	[rad/Nm]	0.0	0.0	0.0	0.0	0.0	0.0

Side Force Steer

