Department of Automotive Technologies –
Vehicle Mechanics Fundamentals

Gábor Sipos

DEPARTMENT OF AUTOMOTIVE TECHNOLOGIES

Lecture 8

Basic information

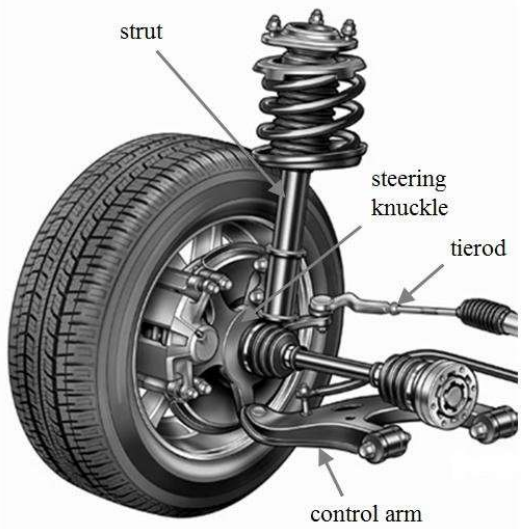
DEPARTMENT OF AUTOMOTIVE TECHNOLOGIES

Week nr.	Official nr.	Date	Lecture (Monday)		Lab (date+1;Tuesday)	
1	1	12th Feb	1	General information, Tyre, Driving force	1	Lab
2	2	19th Feb	2	Longitudinal and lateral behaviour		
3	3	26th Feb	3	Concepts and over/understeer	2	Lab
4	4	4th Mar	4	Weight transfer		
5	5	11th Mar	5	Bicycle model	3	Lab
6	6	18th Mar	T1	Midterm exam I. ONLINE		
7	7	25th Mar	6	Braking and brakes ONLINE	4	Lab ONLINE
8		1st Apr	-	Break		
9	8	8th Apr	7	Systems of the vehicle		
10	9	15th Apr	8	Quarter vehicle model ONLINE	T1 R	Exam 1 - subsequent ONLINE
11	10	22th Apr		Break		
12	11	29th Apr	T2	Midterm exam II. ONLINE		Break
13	12	6th May	9	Tyre management		
14	13	13th May	10	Racecar engineering	T2 R	Exam 2 - subsequent
	14	20th May	11	Semester championship presentation		

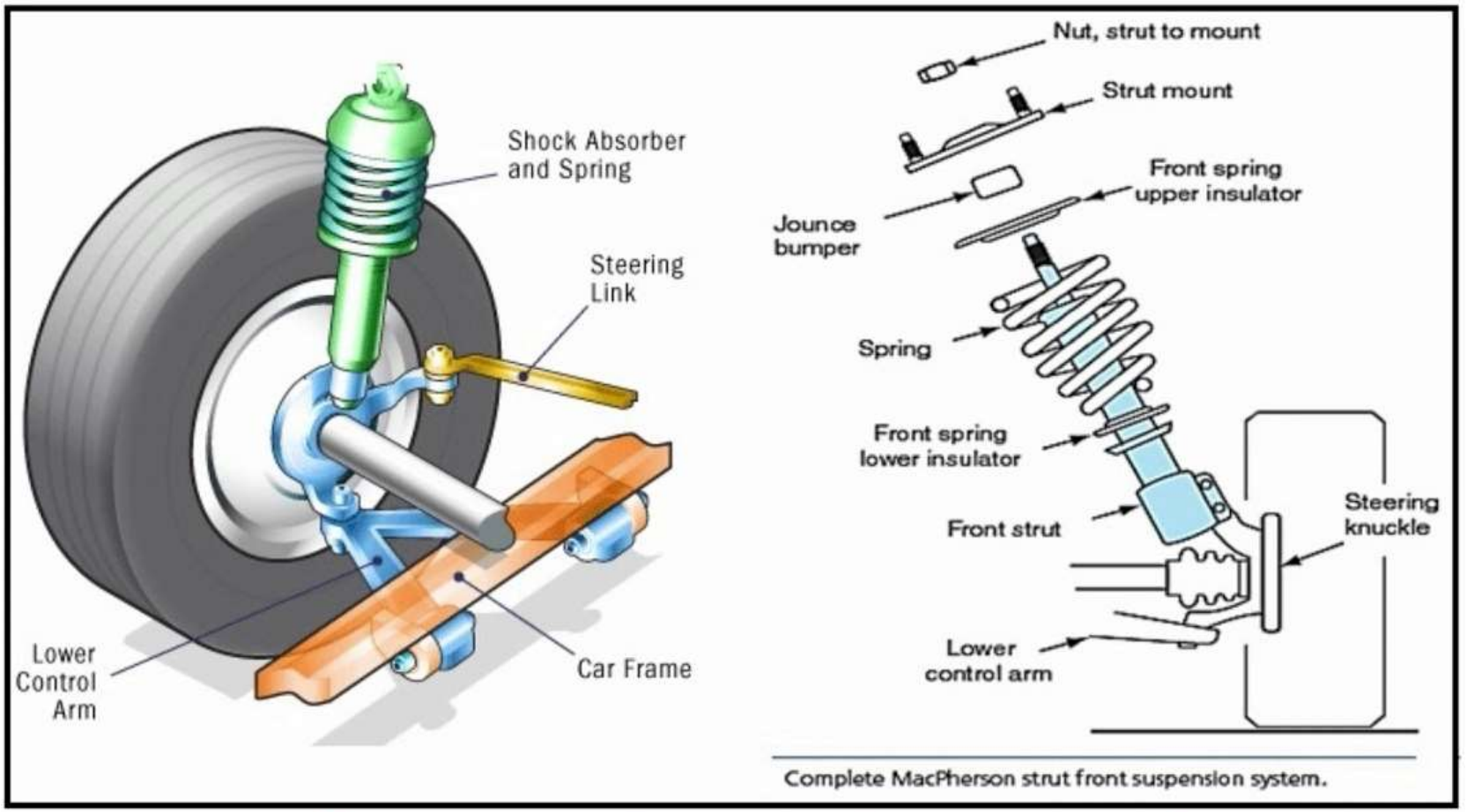
Quarter vehicle model

Functions of suspension

- reducing impulse forces: improved structural reliabilityo f bodywork
- passenger comfort as isolating bodywork from the road
- vehicle handling: steady state - springs; transient - spring+damper; influence to load transfer
- normal force on tyre depends on suspension
- keep tyre grip high - temperature+load variation
- aero - osciallations to prevent, control movement,spring platform heights
- control chassis movements - pitch, roll



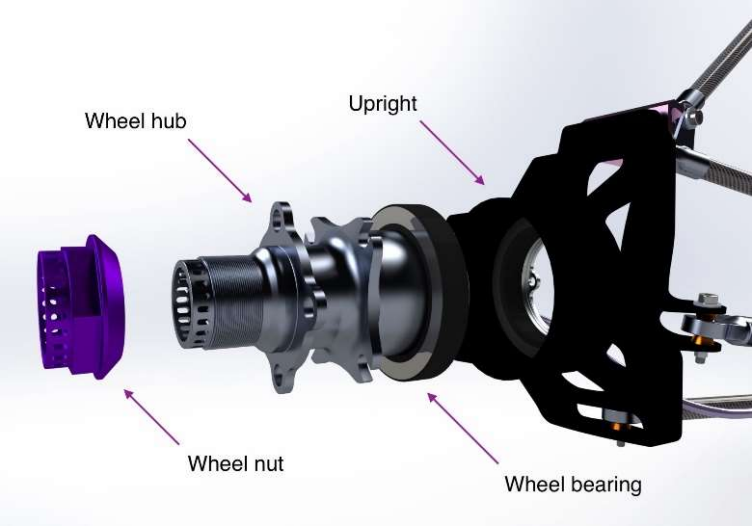
Functions of suspension

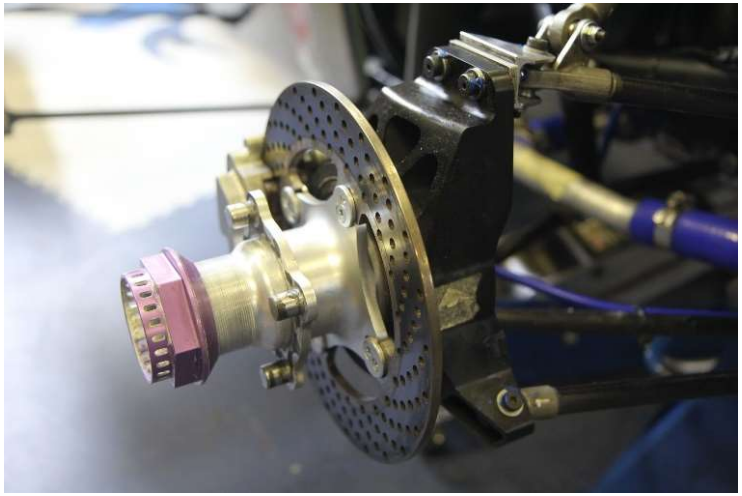


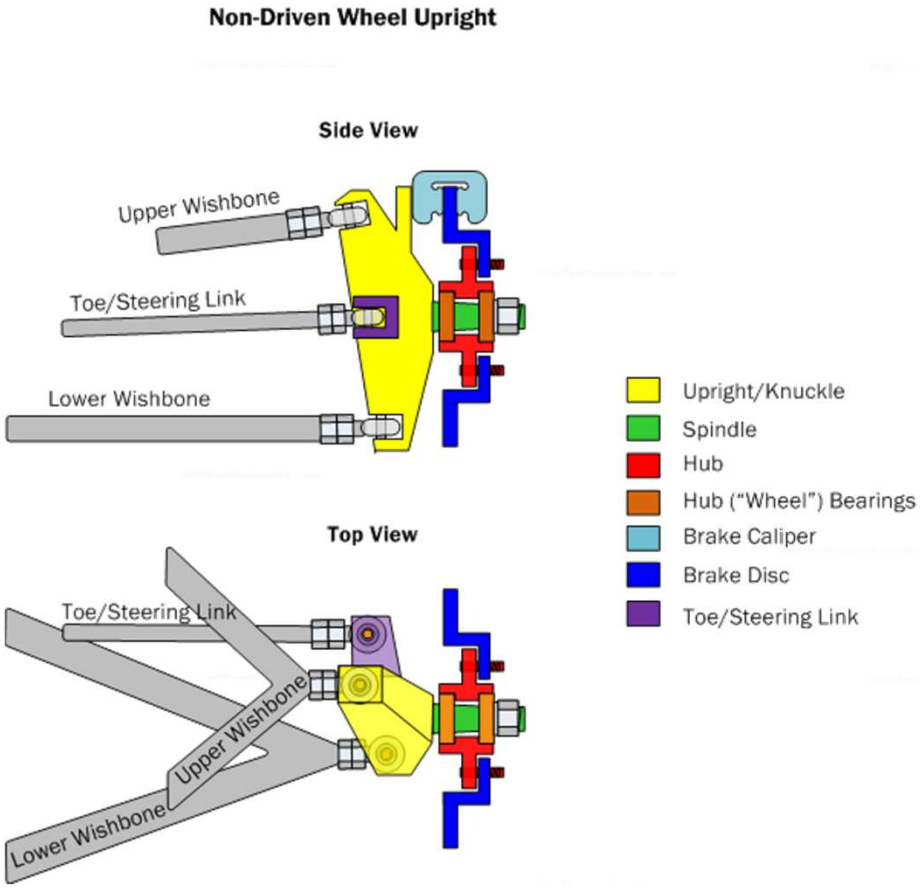
MacPherson Strut Suspension

Quarter vehicle model

Functions of suspension

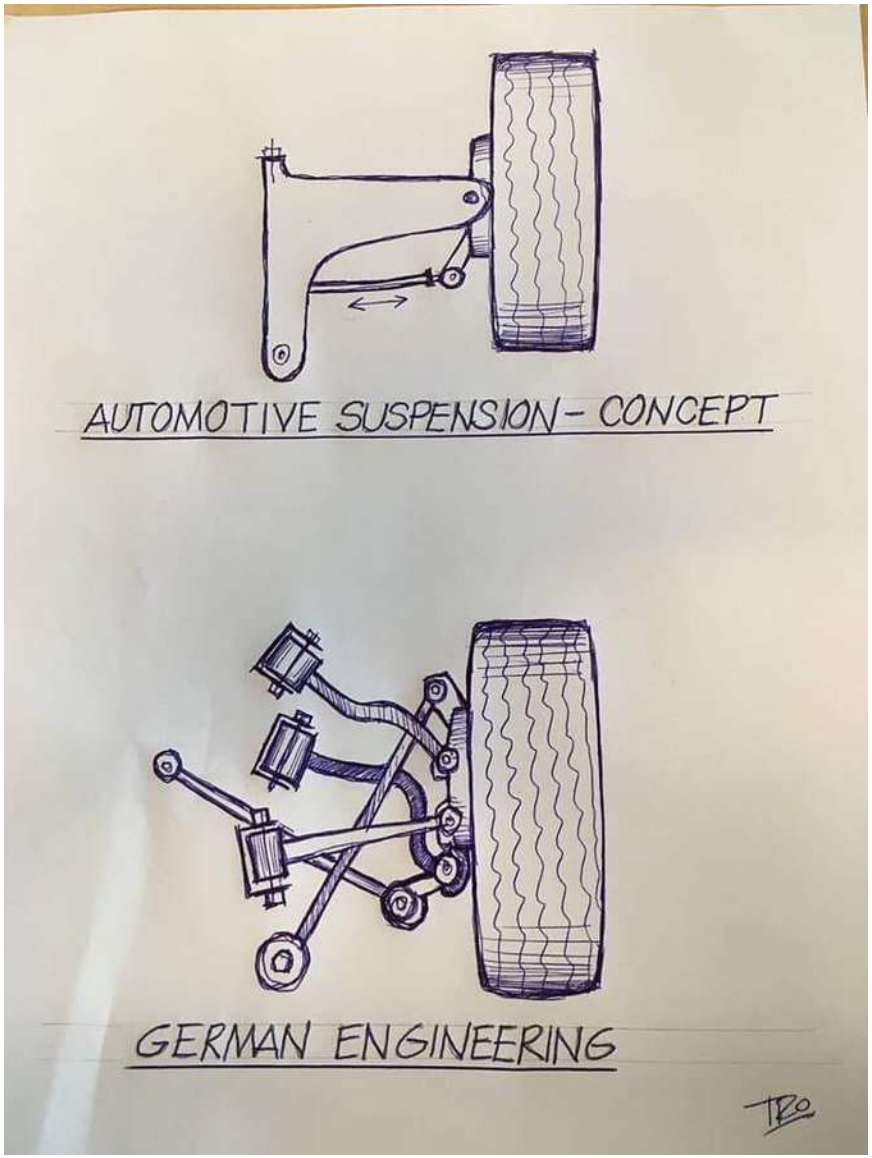


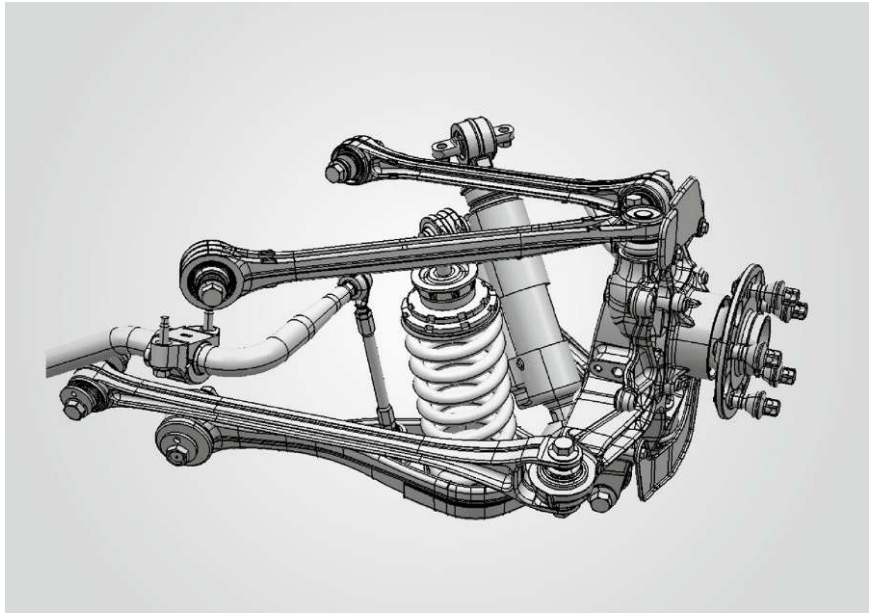




Quarter vehicle model

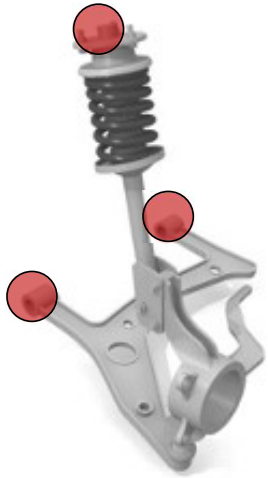
Functions of suspension

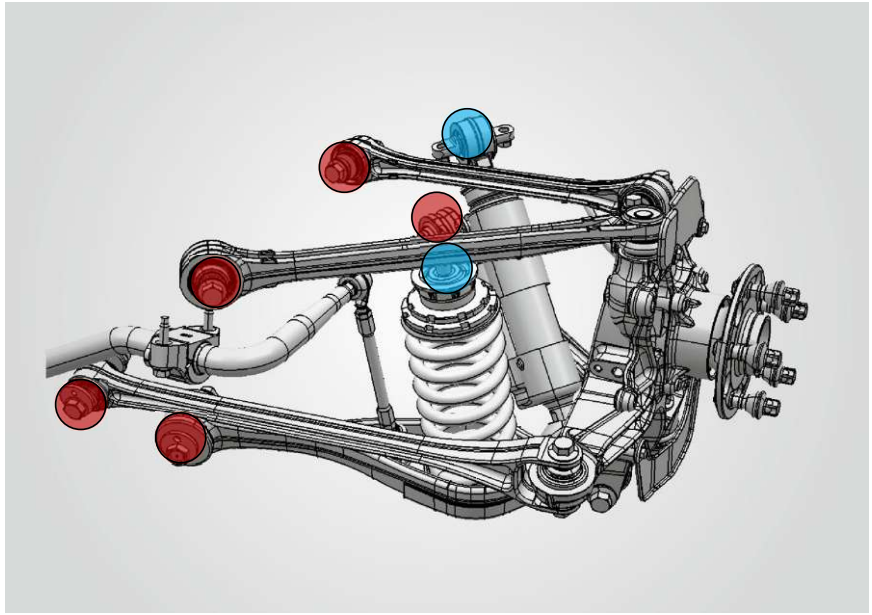




Quarter vehicle model

Functions of suspension





Quarter vehicle model

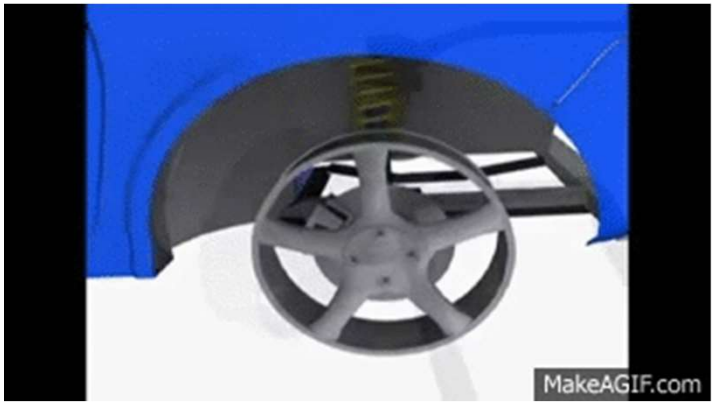
Functions of suspension

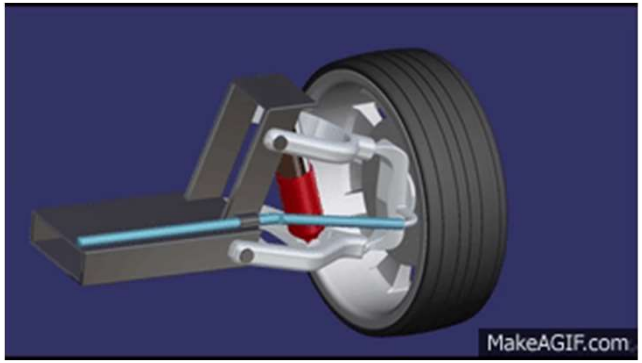
MACPHERSON STRUT

DOUBLE WISHBONE

MULTI-LINK

TRAILING-ARM





Quarter vehicle model

Functions of suspension

MACPHERSON STRUT

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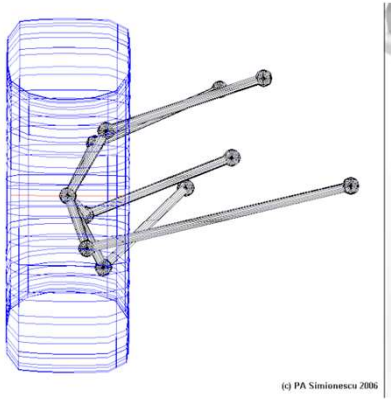
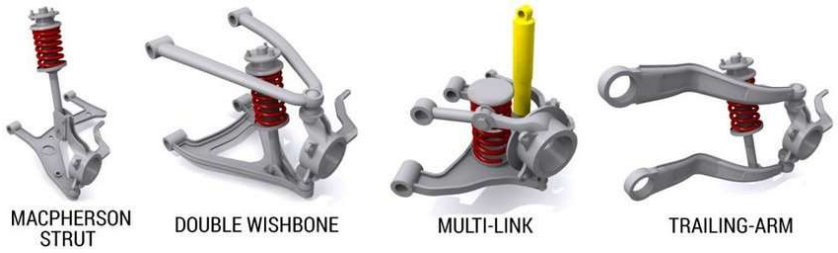
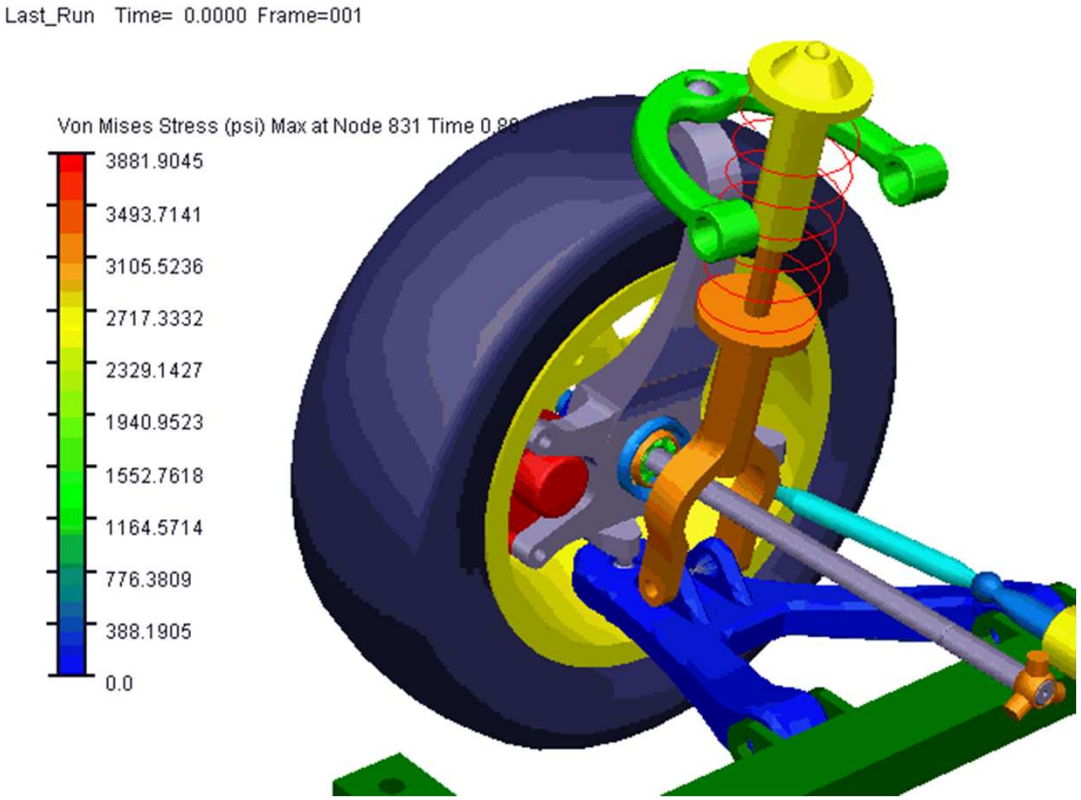


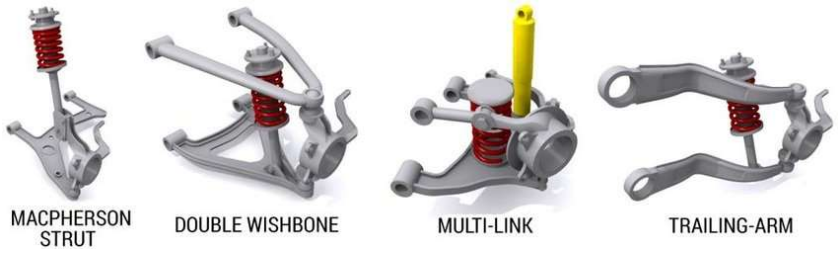
Quarter vehicle model

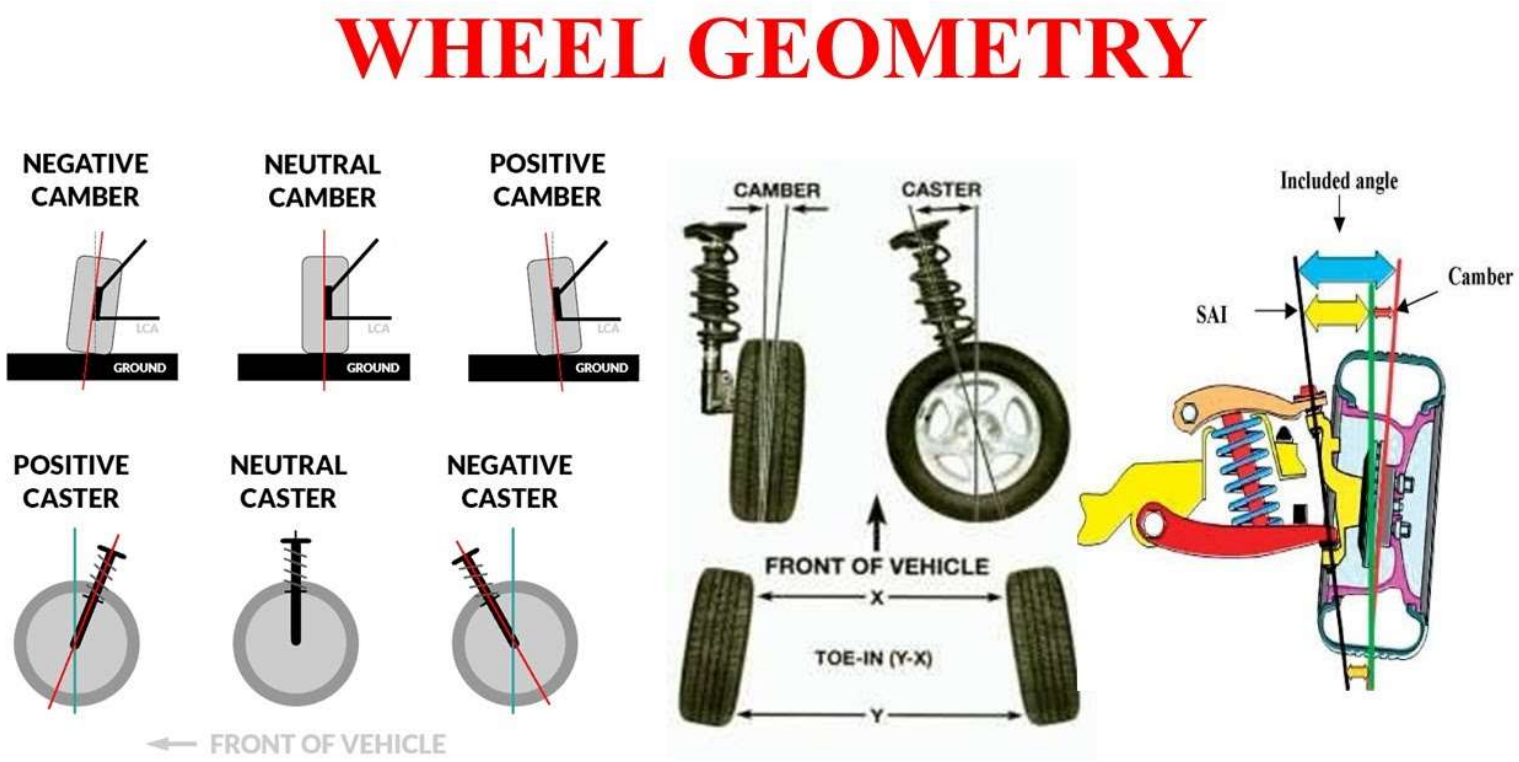
Functions of suspension





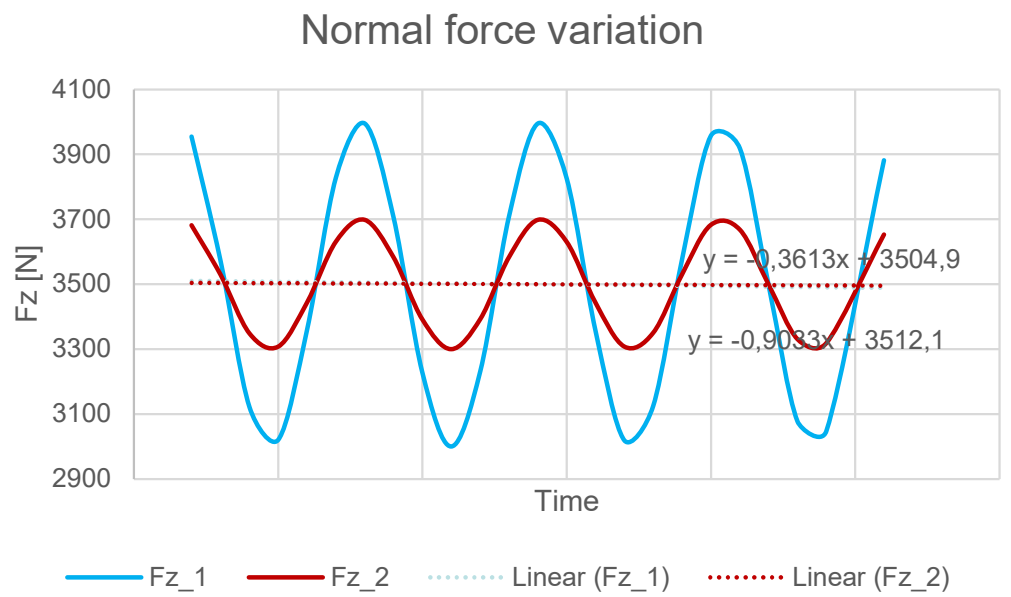
Functions of suspension

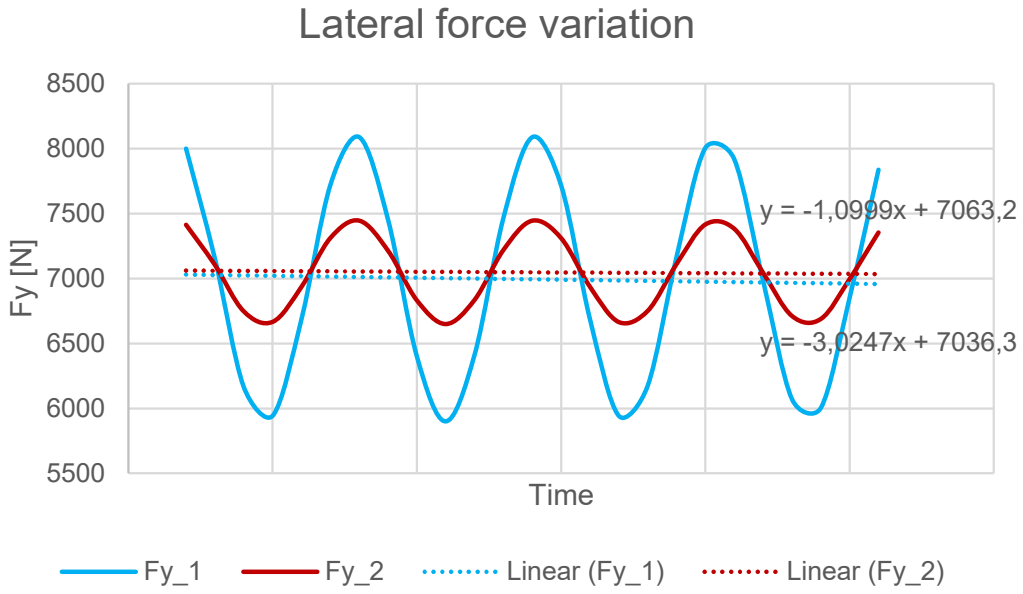




Quarter vehicle model

Damping



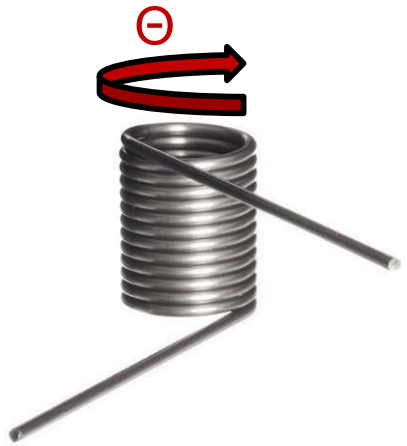


Quarter vehicle model

Springs and dampers

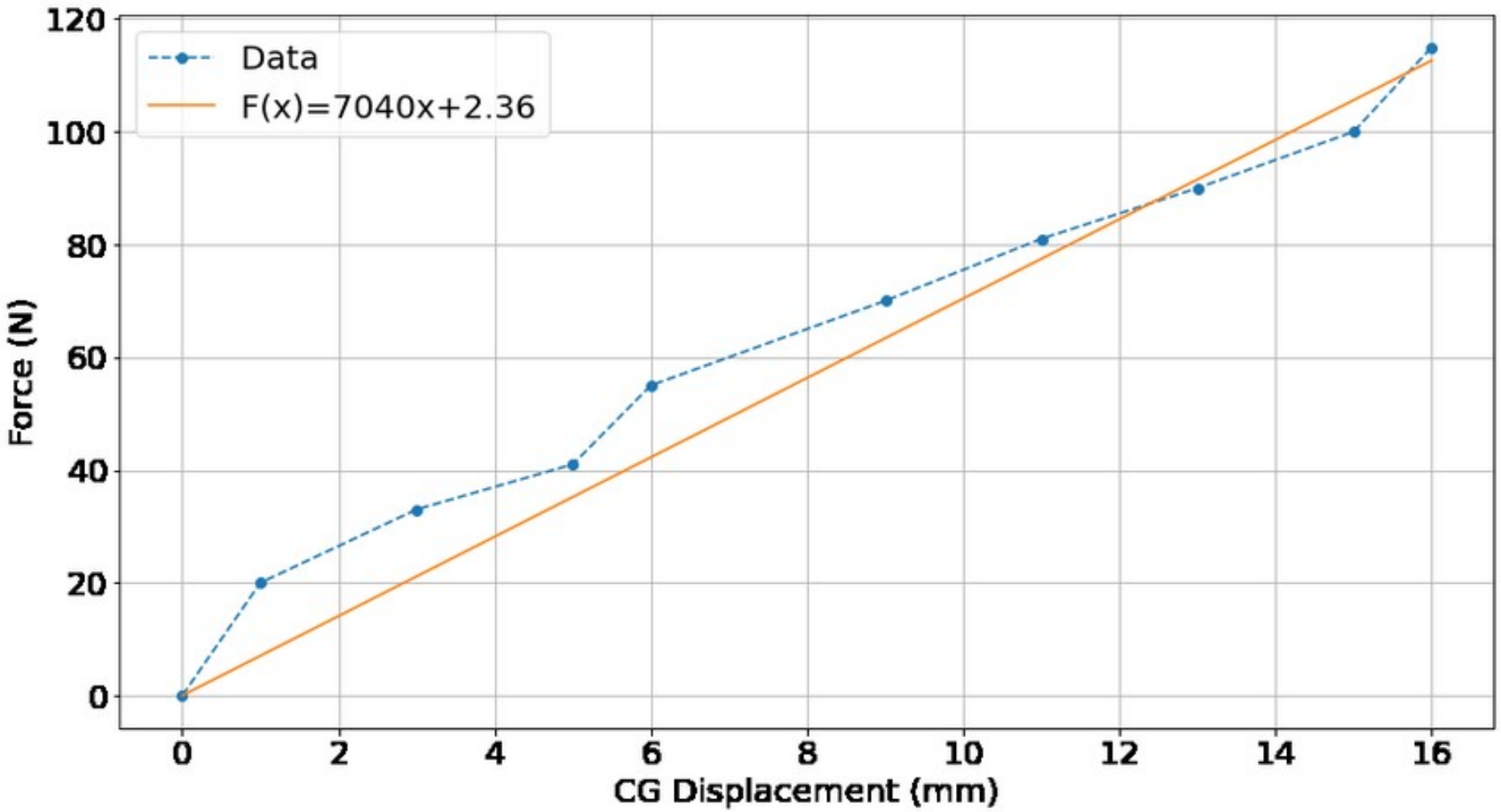
- linear springs
  - $F=k \cdot x$
    - F spring force [N]
    - k stiffness (linear) [N/m]
    - x spring compression [m]

- torsional springs
  - $T=k_t \cdot \Theta$
    - T spring torque [Nm]
    - k_t angular stiffness [Nm/rad]
    - Θ torsional spring compression [rad]



Quarter vehicle model

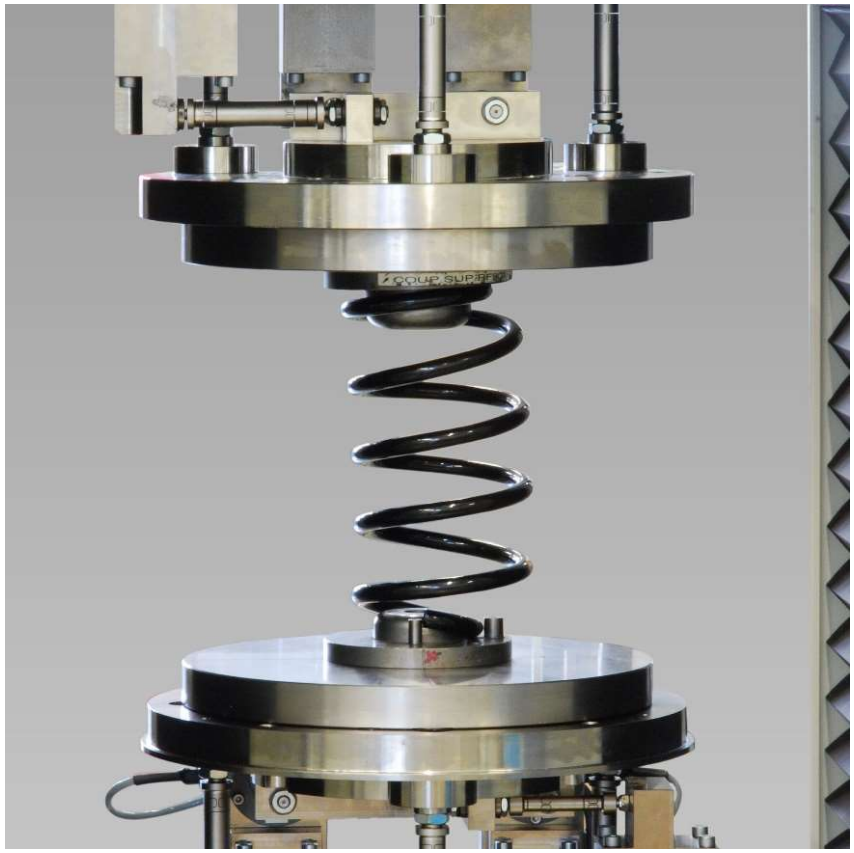
Springs and dampers



Spring stiffness real shape!

Quarter vehicle model

Springs and dampers



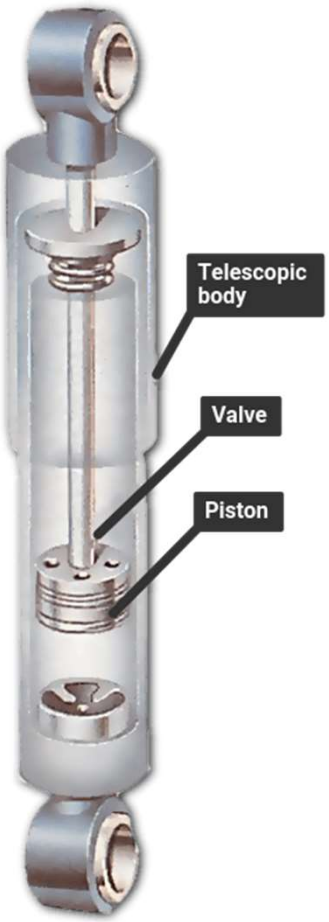
Spring stiffness measurement

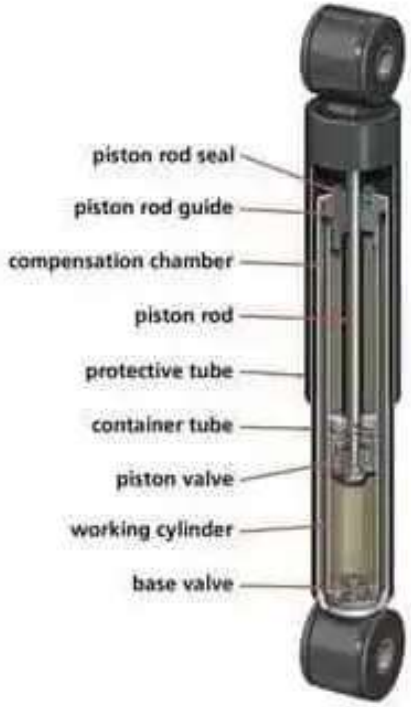
Quarter vehicle model

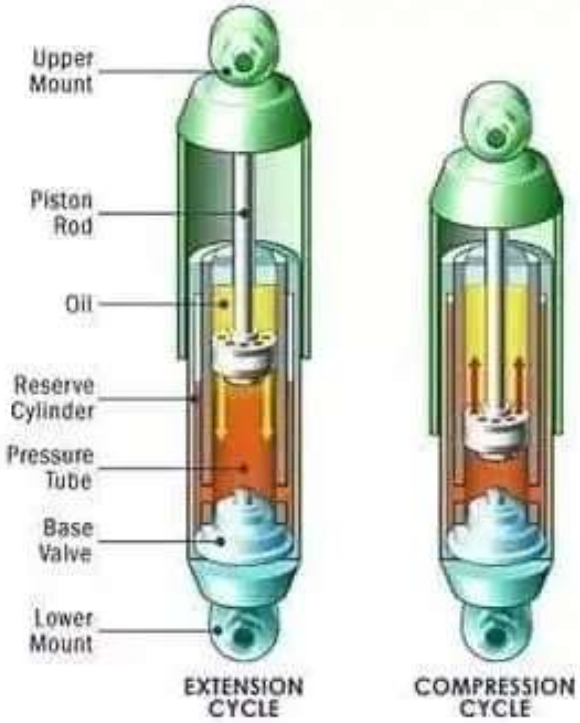
Springs and dampers

Quarter vehicle model

Springs and dampers

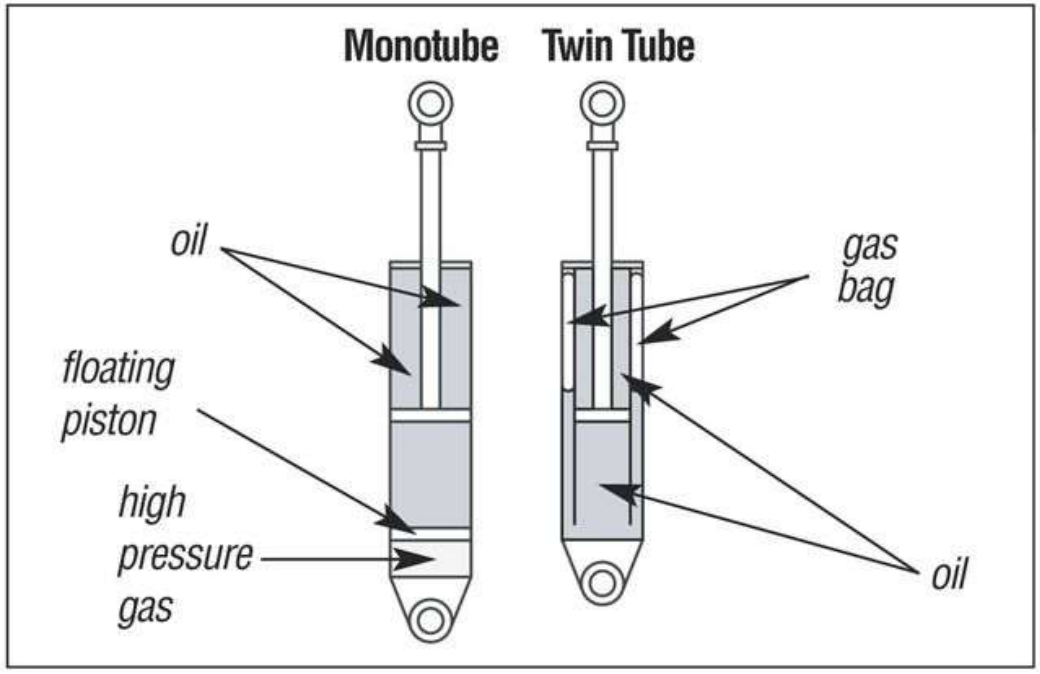






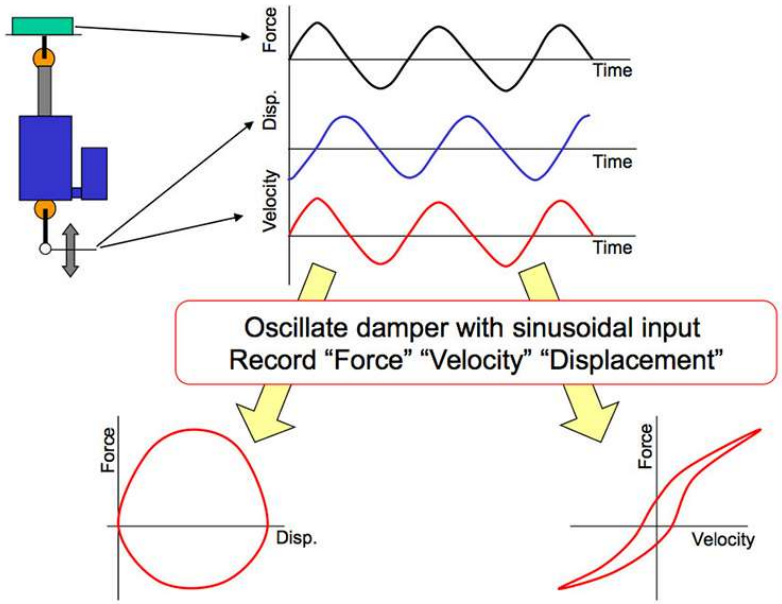
Quarter vehicle model

Springs and dampers



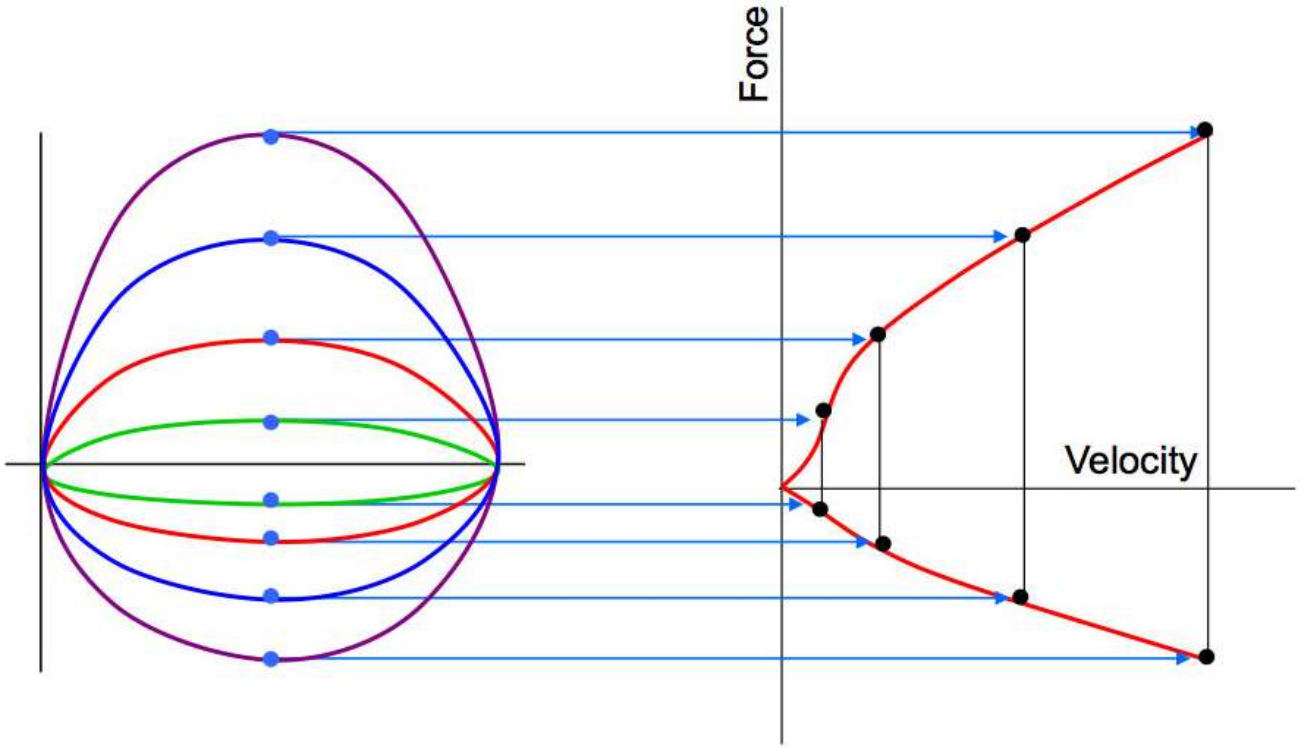
Quarter vehicle model

Springs and dampers



Springs and dampers

•Plot the peak value of each run on a Force-Velocity graph



Springs and dampers

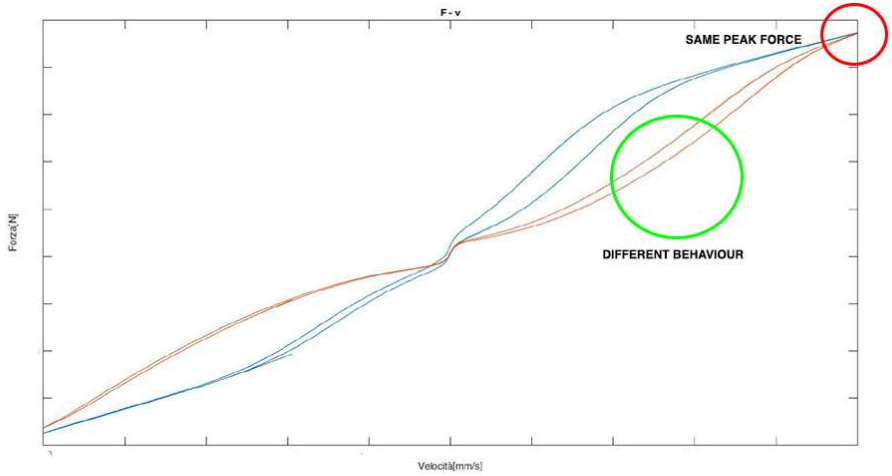
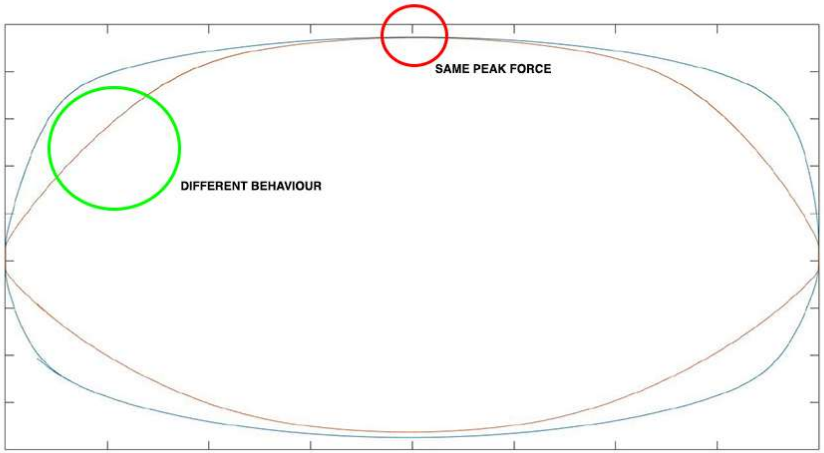
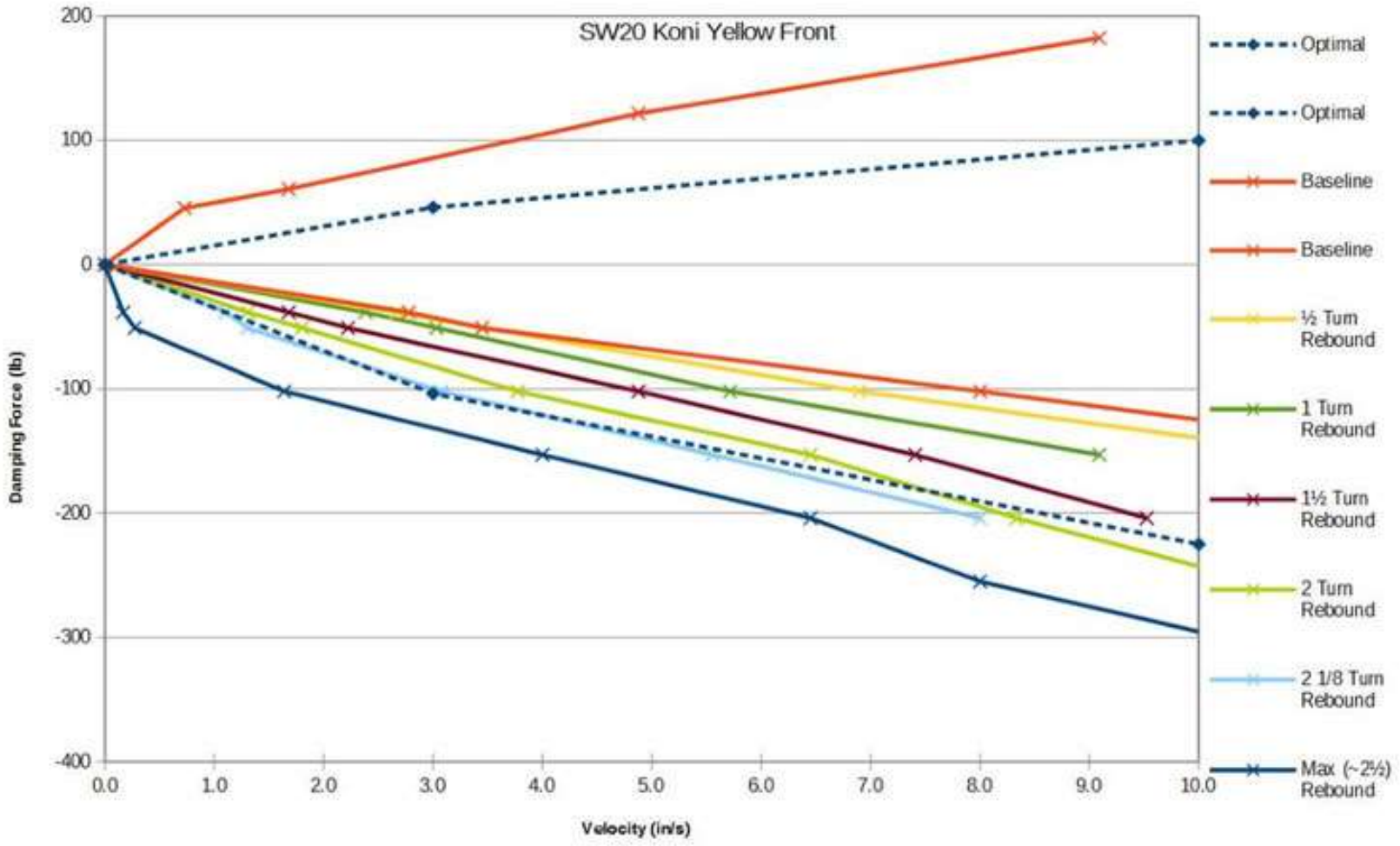


Figura 3: Force - velocity difference



Quarter vehicle model

Springs and dampers



https://suspensionsecrets.co.uk/dampers-set-up/

Quarter vehicle model

Springs and dampers

- fluid is incompressible - piston+valve
- funtions
  - weight transfer and chassis motion
  - stiffer dampers increase rate of WT and decrease the speed of the body motions
  - unsprung oscillations
  - tire contact patch consistency
- damping coefficient
  - c=F/v
    - c - damping coefficient [N/(mm/s)]
    - F - damper force [N]
    - v - damper piston speed [N/(mm/s)]

Quarter vehicle model

Springs and dampers

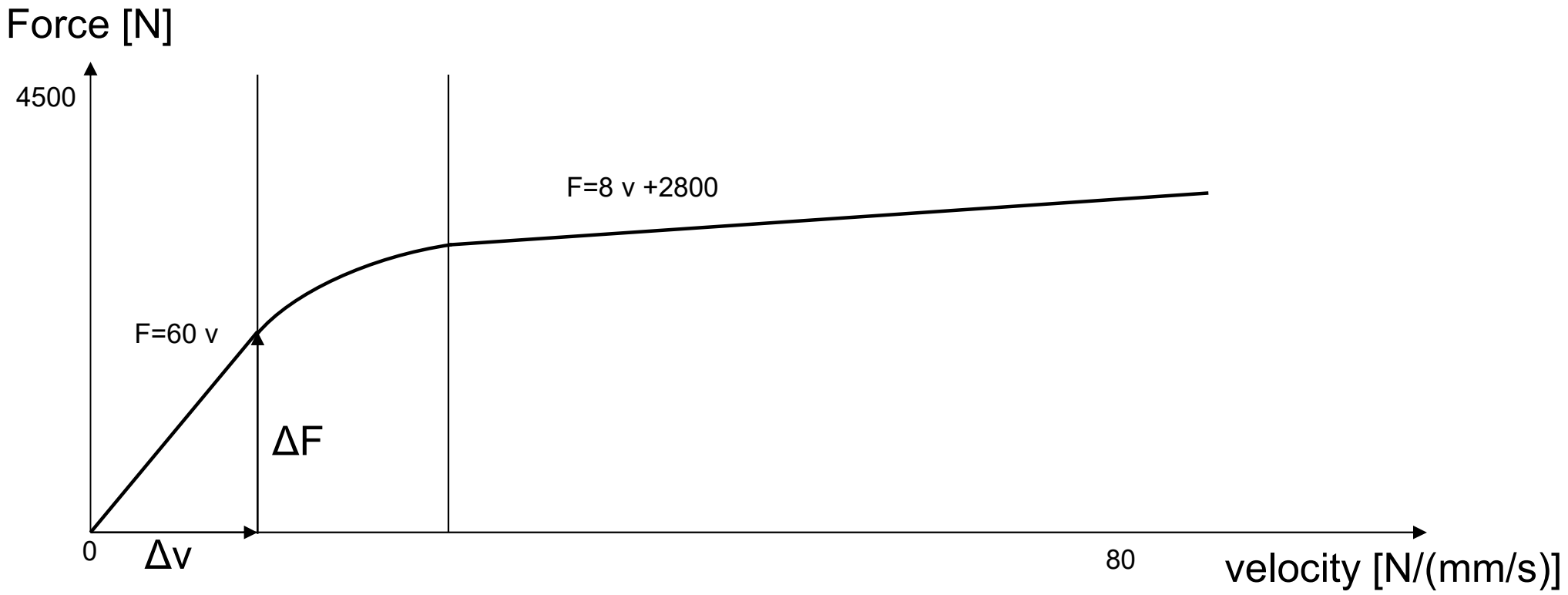
- fluid is incompressible - piston+valve
- funtions
  - weight transfer and chassis motion
  - for dampers increase rate of WT and decrease the speed of the body
  - ...llations
  - tire cont... ...sistency
- damping coefficien...
  - c=F/v
    - c - damping coefficient [N/(mm/s)]
    - F - damper force [N]
    - v - damper piston speed [N/(mm/s)]

Is this true?

Quarter vehicle model

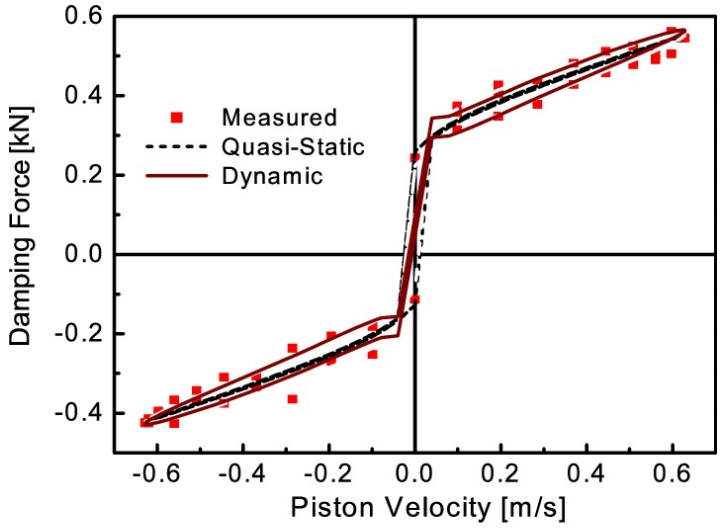
Springs and dampers

- damping coefficient
  - c=F/v
    - c - damping coefficient [N/(mm/s)]
    - F - damper force [N]
    - v - damper piston velocity [N/(mm/s)]

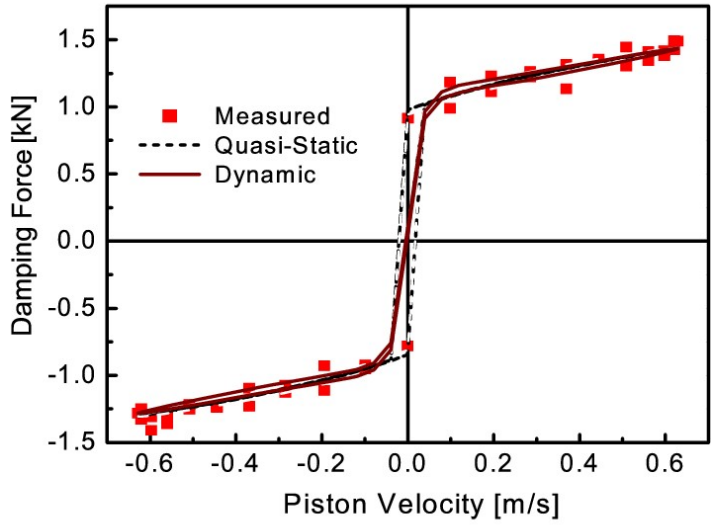


Quarter vehicle model

Springs and dampers



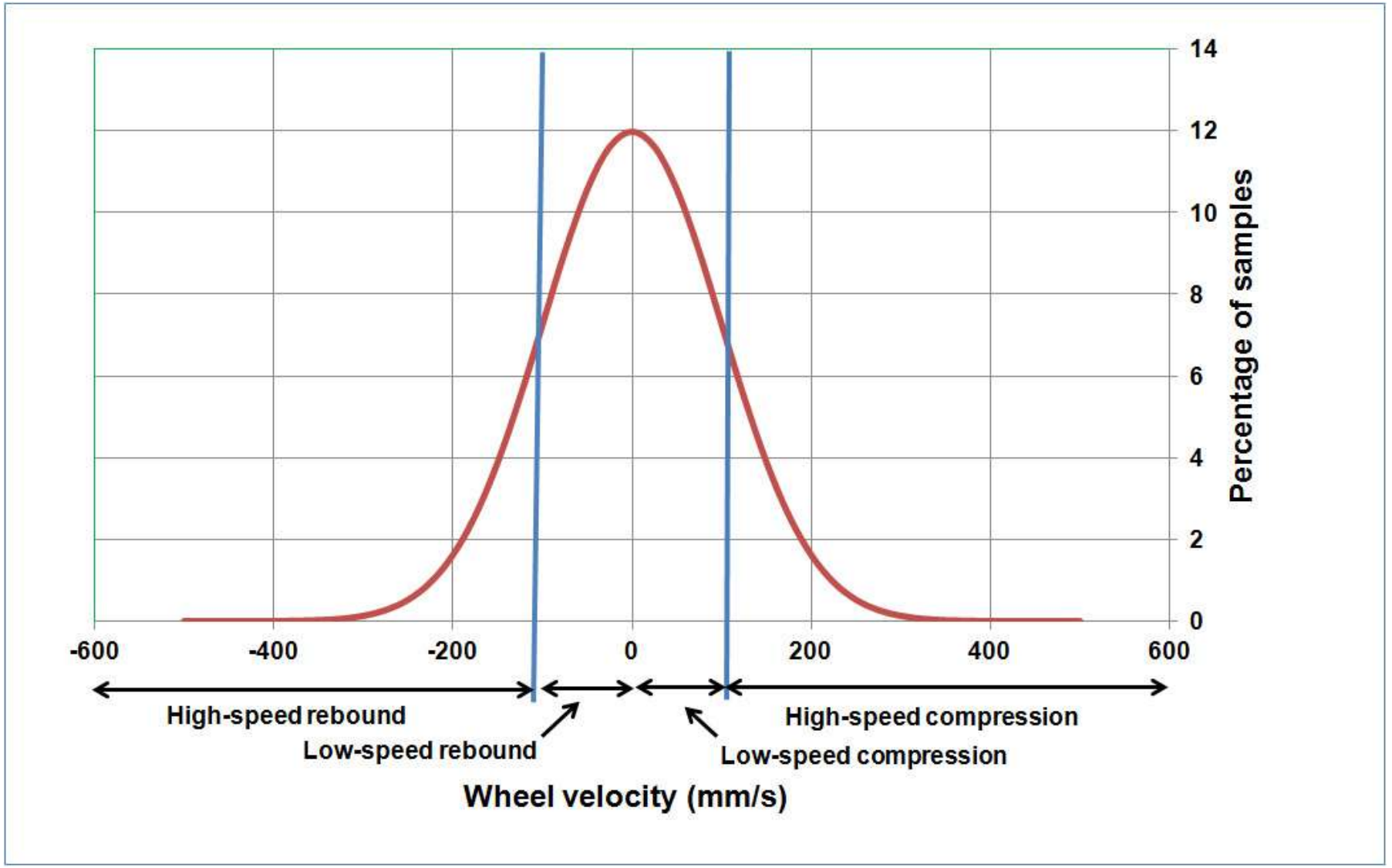
(a)



(b)

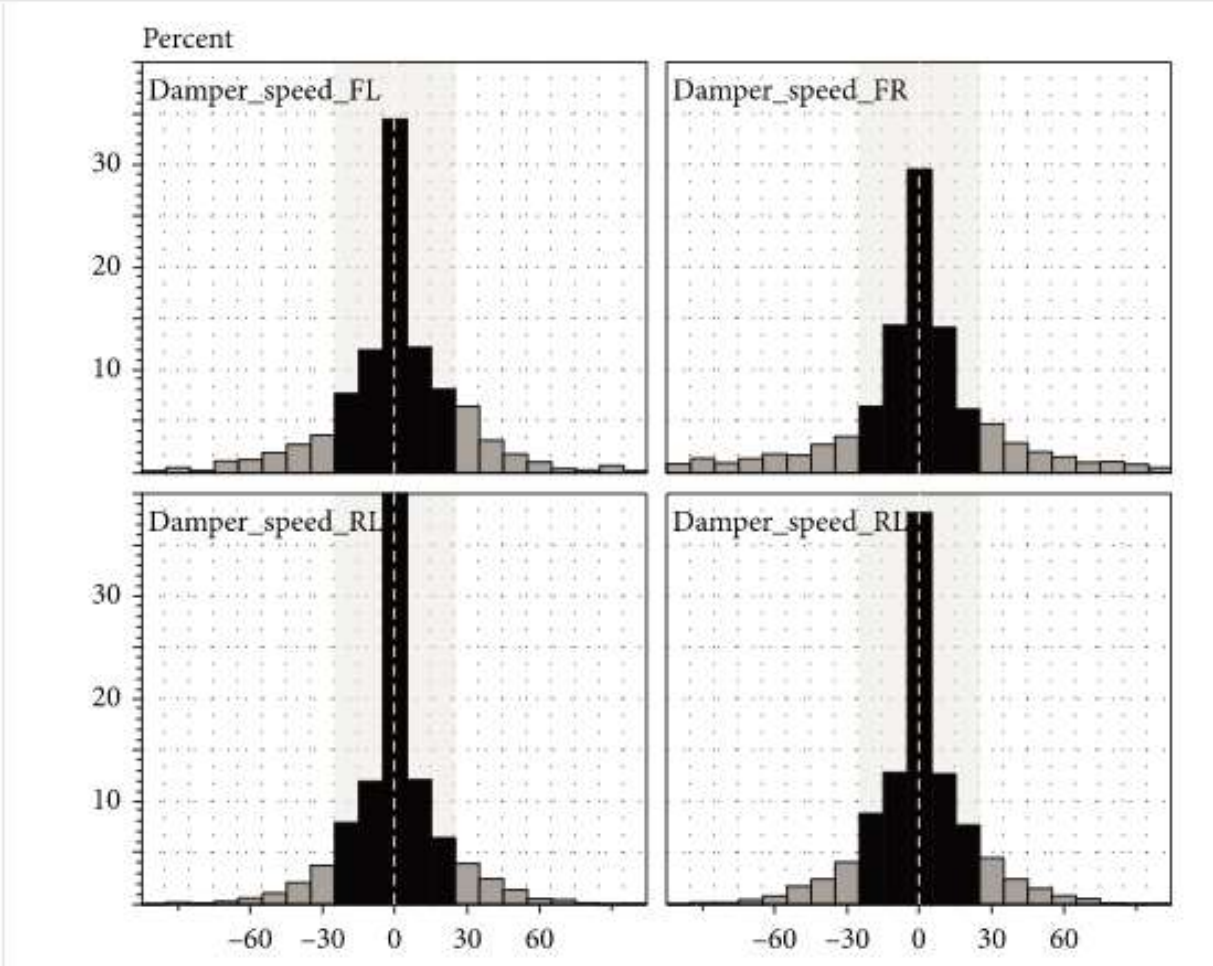
Quarter vehicle model

Springs and dampers



Quarter vehicle model

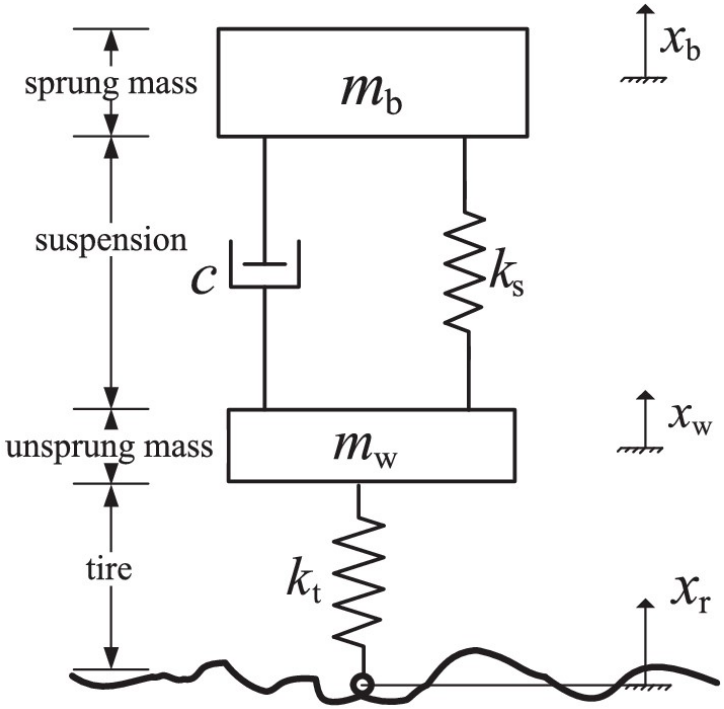
Springs and dampers

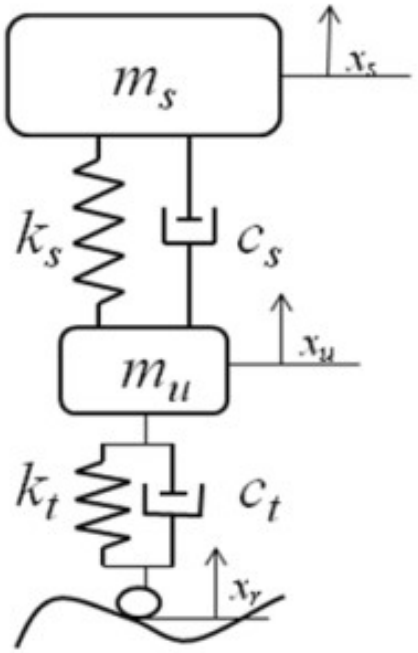


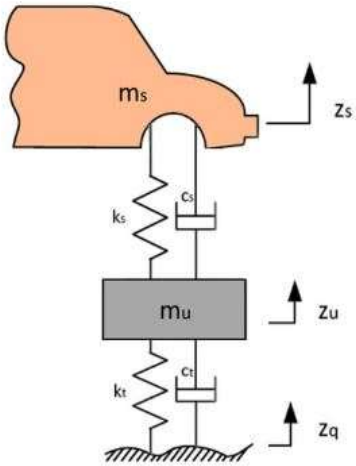
Quarter vehicle model

MoTec example histogram and track map

Quarter vehicle model







Quarter vehicle model

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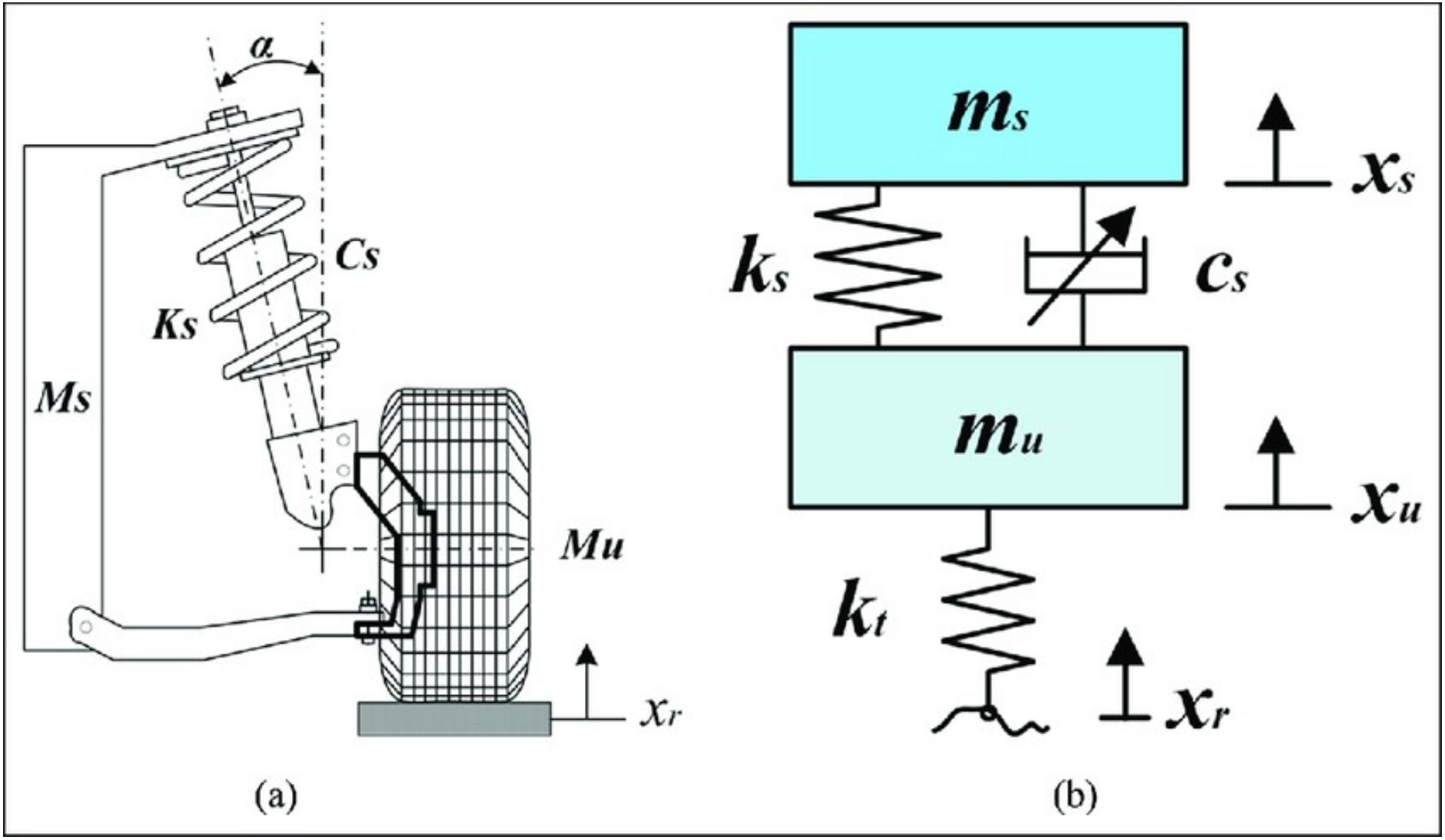
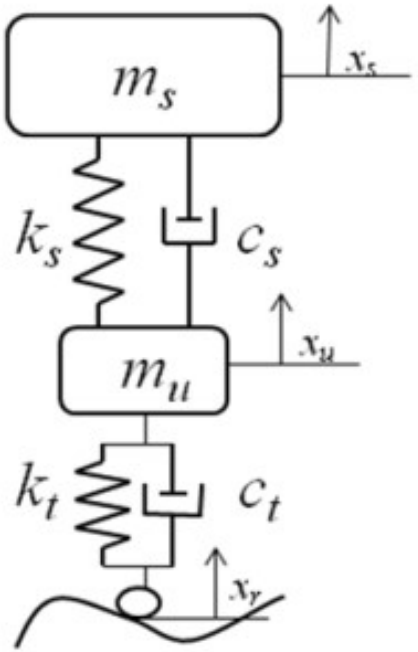


Quarter vehicle model



$$m_s\ddot{x}_s - c_s(\dot{x}_s - \dot{x}_u) - k_s(x_s - x_u) = 0$$

$$m_u\ddot{x}_u + c_s(\dot{x}_s - \dot{x}_u) + k_s(x_s - x_u) - c_t(\dot{x}_u - \dot{x}_r) - k_t(x_u - x_r) = 0$$

x_s = Vehicle body motion,
x_u = Wheel body motion,
x_r = Road velocity,
k_s ,k_t = Suspension & Tire spring rates respectively, $\frac{N}{m}$
c_s ,c_t = Suspension & Tire damping respectively. $\frac{N}{\frac{m}{s}}$

Quarter vehicle model

https://youtu.be/aNxSigpIhxA?si=LJYUJn_-E-OHN4wh

https://www.youtube.com/watch?v=PwIntnWtqJc

Midterm tests and exams

BME
DEPARTMENT OF AUTOMOTIVE TECHNOLOGIES

1

- know concepts and definitions – you are able to give definitions of :
  - different type of tyre radius
  - contact patch
  - tyre structures
  - slip ratio
  - slip angle
  - aware of the different characteristics of tyre behaviour and able to distinguish one from other
  - friction coefficient
  - brush tyre model and explanation of tyre force
  - able to orientate in the coordinate system of a vehicle
  - cornering stiffnes of a tyre
  - self aligning torque
  - pneumatic trail
  - friction ‚cirle'
  - steady state basics equations
  - transient basics equation
  - characteristics of transient basics diagrams

Midterm tests and exams

2

- assymetric tyre behaviour to acceleration and braking
- static vertical tyre loads
- longitudinal weight transfer with the help of longitudinal model
- lateral weight transfer in steady state cornering
- understanding the effect of tyre degressivity and weight transfer
- braking system components
- optimal brake force distribution
- specific braking force
- EBD basic working principle
- Motorsport relevant braking aspects
- Functional structure
- Powertrain: Types of resistance
- CoP
- Gearbox/Propulsion unit: power and powered machine tuning
- Traction force diagram
- 3 main type of chassis structure
- CoG determination methods

Midterm tests and exams

3

- suspension basics
- brake system elements and working
- quarter vehicle model basics

Bibliography

- https://www.researchgate.net/figure/McPherson-suspension-system_fig8_318466442
- http://moodle.autolab.uni-pannon.hu/Mecha_tananyag/kozuti_jarmurendszerek_szerkezettana/ch13.html
- https://www.youtube.com/watch?v=ArH0lj0SsKg
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- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.datamc.org%2Fdata-acquisition%2Fsuspension-data-analysis%2Fhistograms-and-suspension-velocity-analysis%2F&psig=AOvVaw0yqxvVdgH5nzVWW5R-xZdx&ust=1683620634469000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNCV0-Cl5f4CFQAAAAAdAAAAABAn
- https://www.researchgate.net/profile/Deepak-Unune/publication/259174444_Ride_Analysis_of_Quarter_Vehicle_Model/links/5401653c0cf2c48563aef4ae/Ride-Analysis-of-Quarter-Vehicle-Model.pdf

Thank you for your attention!