Term Project Submission

Vehicle Dynamics

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
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Cornering of Vehicle
(Based on Understeer Gradient Theory)

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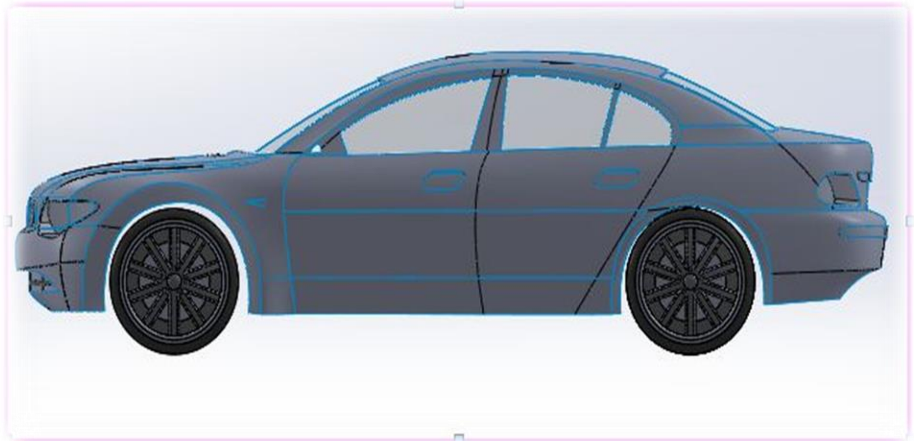
Major Aspects

- Car Body
- Overview
- Bicycle model
- Very slow speed cornering
- High speed cornering
- Understeer gradient
- Stability analysis with Graphs
- Conclusion
- References

Car Body

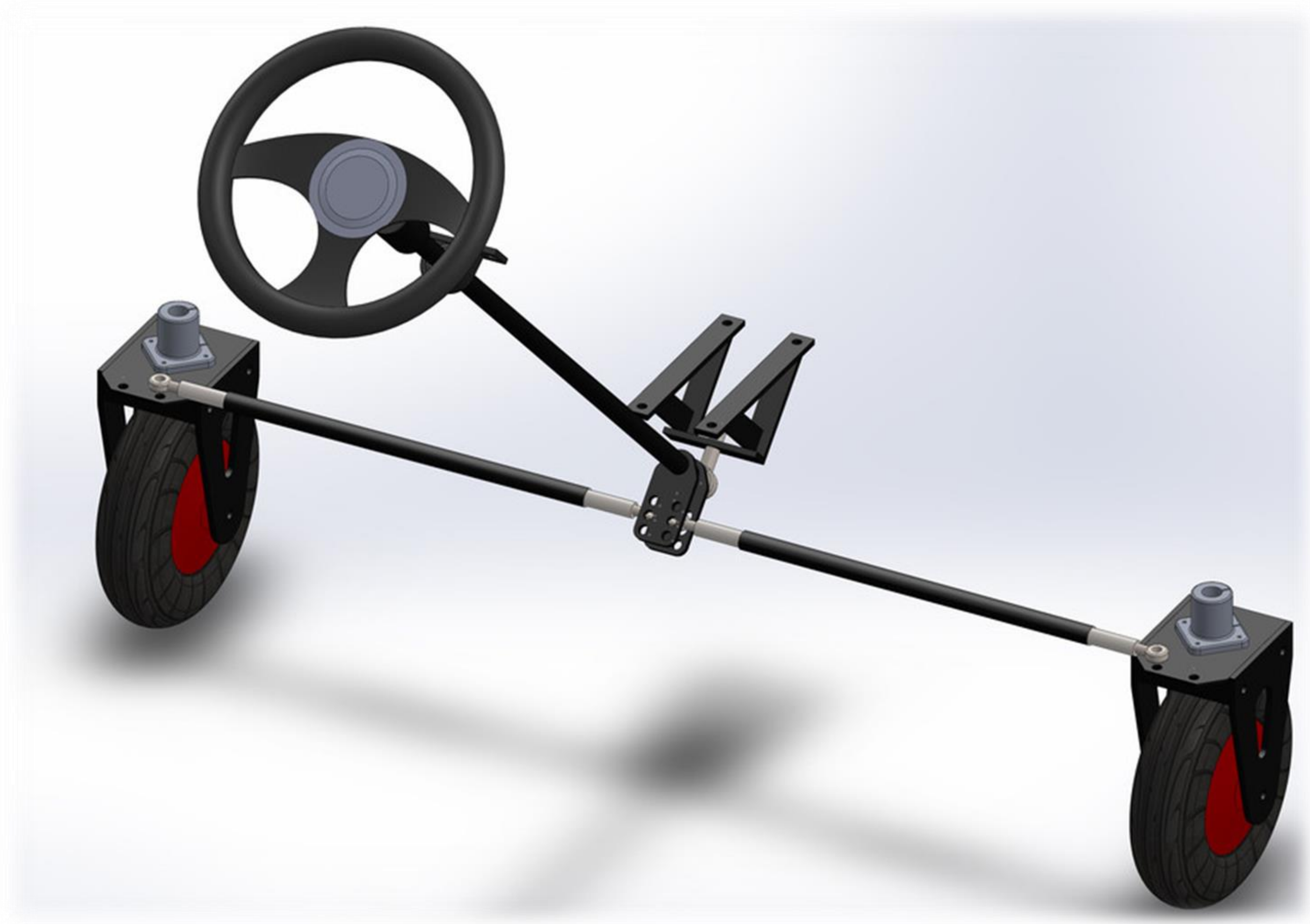
A surface model of AUDI RS4 B7 (Sedan) [5]
Made in Solid Works Design Software

Side View of Solid part after and before rendering in preview mode



Oblique View of Solid part after and before rendering in preview mode

Steering Assembly



Overview

- Controllability of the vehicle.
  - Disturbances
  - Dynamic responses.

- Consequences as a output.
  - Environmental input
  - Feedback from the automobile system
  - Driver motive

Bicycle model

- Simplified model
  - Basic representation
- Neglecting minor effects
  - Longitudinal and lateral load transfer
  - Rolling and pitching motion
  - Aerodynamic and suspension compliance effect.
- Degree of freedom
  - Lateral velocity (v)
  - Yaw velocity (r)

Very slow speed cornering

- Governing parameters
  - Slip angles
  - Lateral accelerations
- Ackermann steering angle

$$-\delta = \frac{L}{R}$$

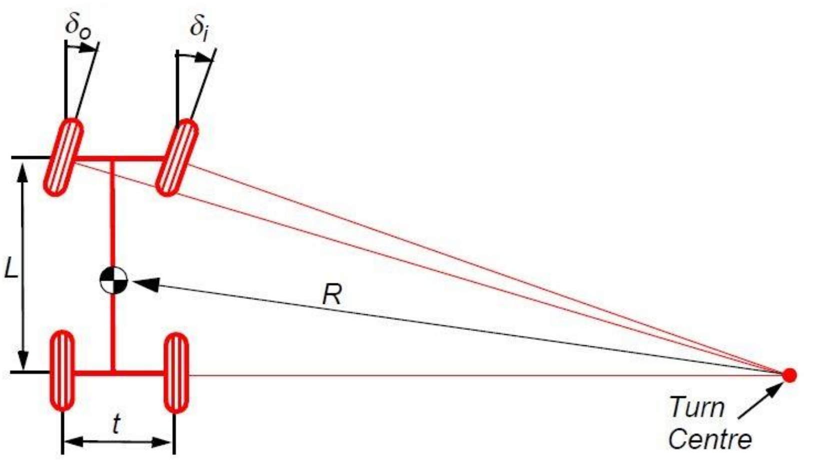


Figure : Slow Speed Cornering [1]

High speed cornering

- Governing parameters
  - Slip angles
  - Lateral accelerations

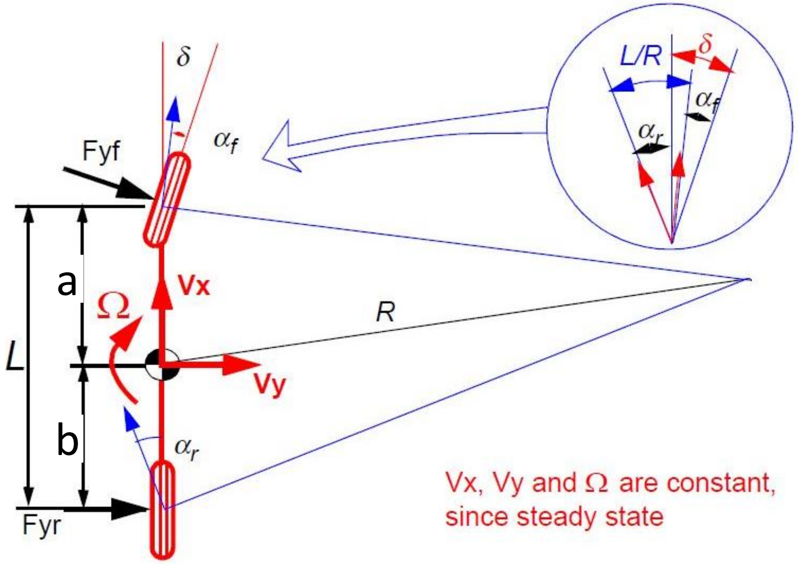


Figure : High Speed Cornering [1]

High speed cornering

- Other dynamic parameters
  - Slip angles for body ,front and rear axle
    - $\beta = \frac{v}{V}; \alpha_F = \frac{v+ar}{V} - \delta; \alpha_R = \frac{v-br}{V}.$
  - Cornering stiffness
    - $C_\alpha = \frac{F_y}{\alpha}.$
  - Load on front and rear axle
    - $W_f = \frac{Wb}{L}; W_r = \frac{Wa}{L}.$

High speed cornering

– Moment equilibrium gives

- $F_{yf}a - F_{yr}b = 0.$

– Tire forces

- $F_{yf} = \frac{W_f V^2}{gR}; F_{yr} = \frac{W_r V^2}{gR}.$

– Understeer gradient

- K$= \frac{W_f}{gC_{af}} - \frac{W_r}{gC_{ar}}.$

$$\sum F_y = F_{yf} + F_{yr} = M\frac{V^2}{R}$$

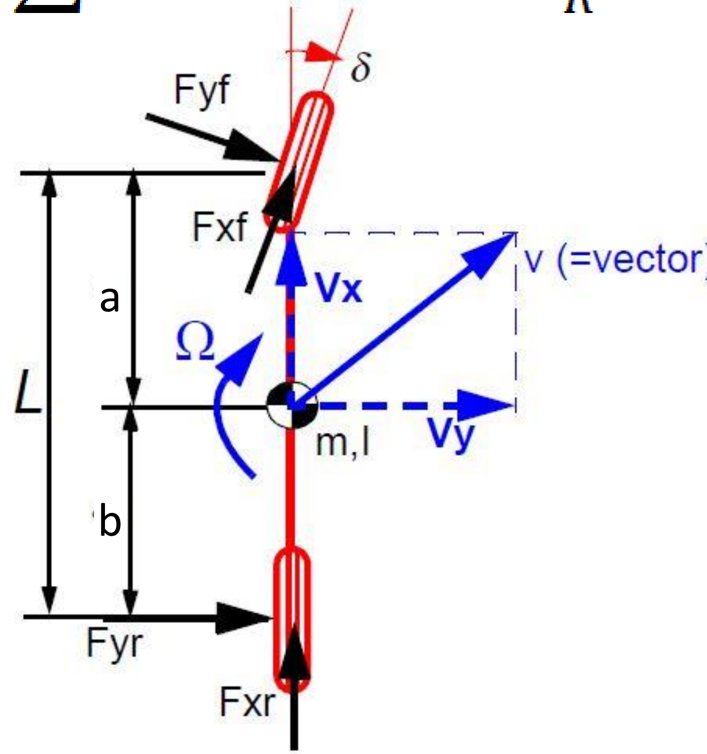
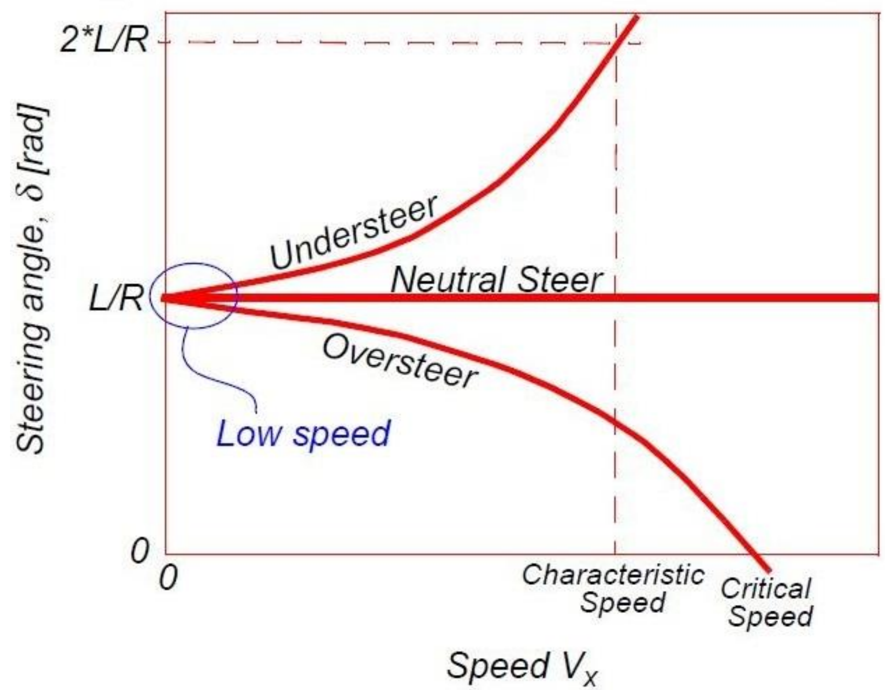


Figure : High Speed Cornering [1]

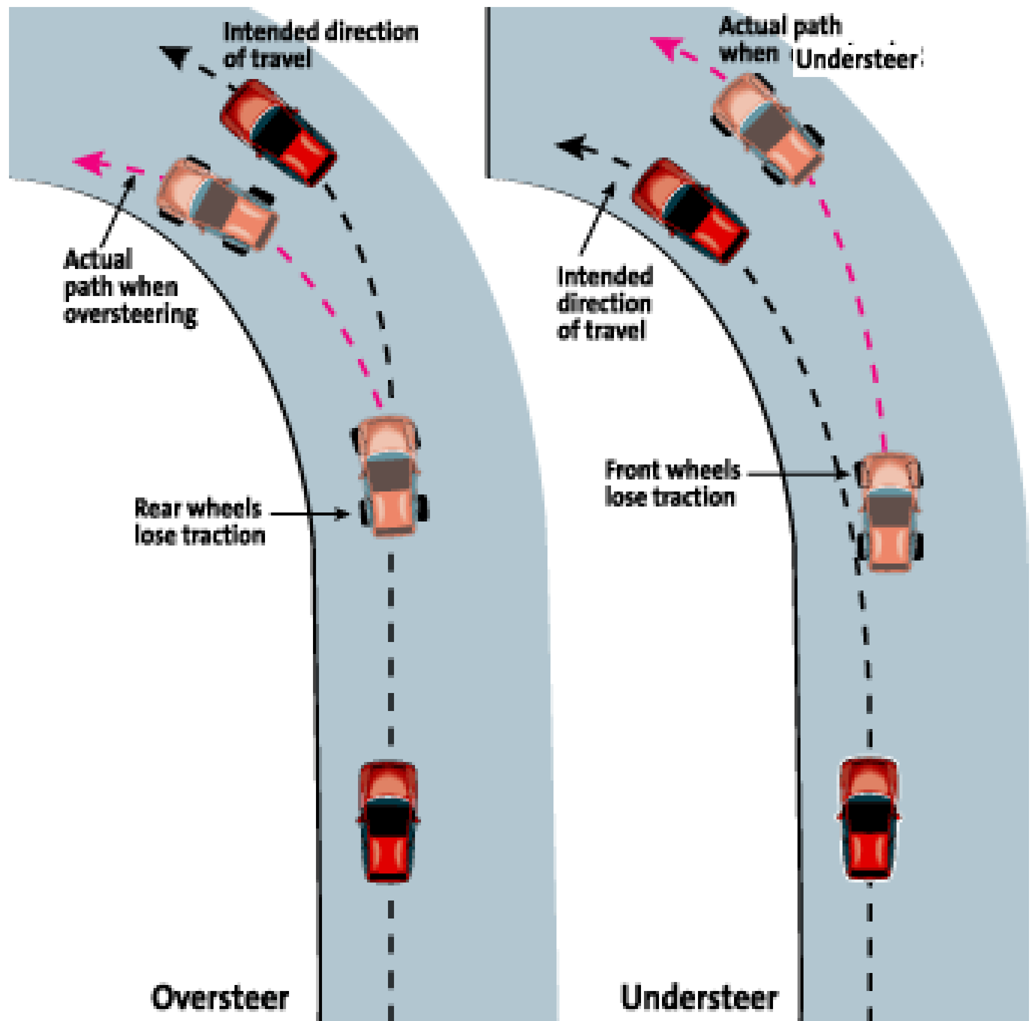
Understeer gradient

- Conditions for understeer gradient
  - Positive
  - Zero
  - Negetive
- Characteristic speed
  - V= $\sqrt{\frac{57.3Lg}{K}}$.
- Critical speed
  - V= $\sqrt{-\frac{57.3Lg}{K}}$.



K=0 Neutral Steer
K>0 Under Steer
K<0 Over Steer

Understeer , Over steer and Neutral steer



Stability analysis with Graphs using CARSIM

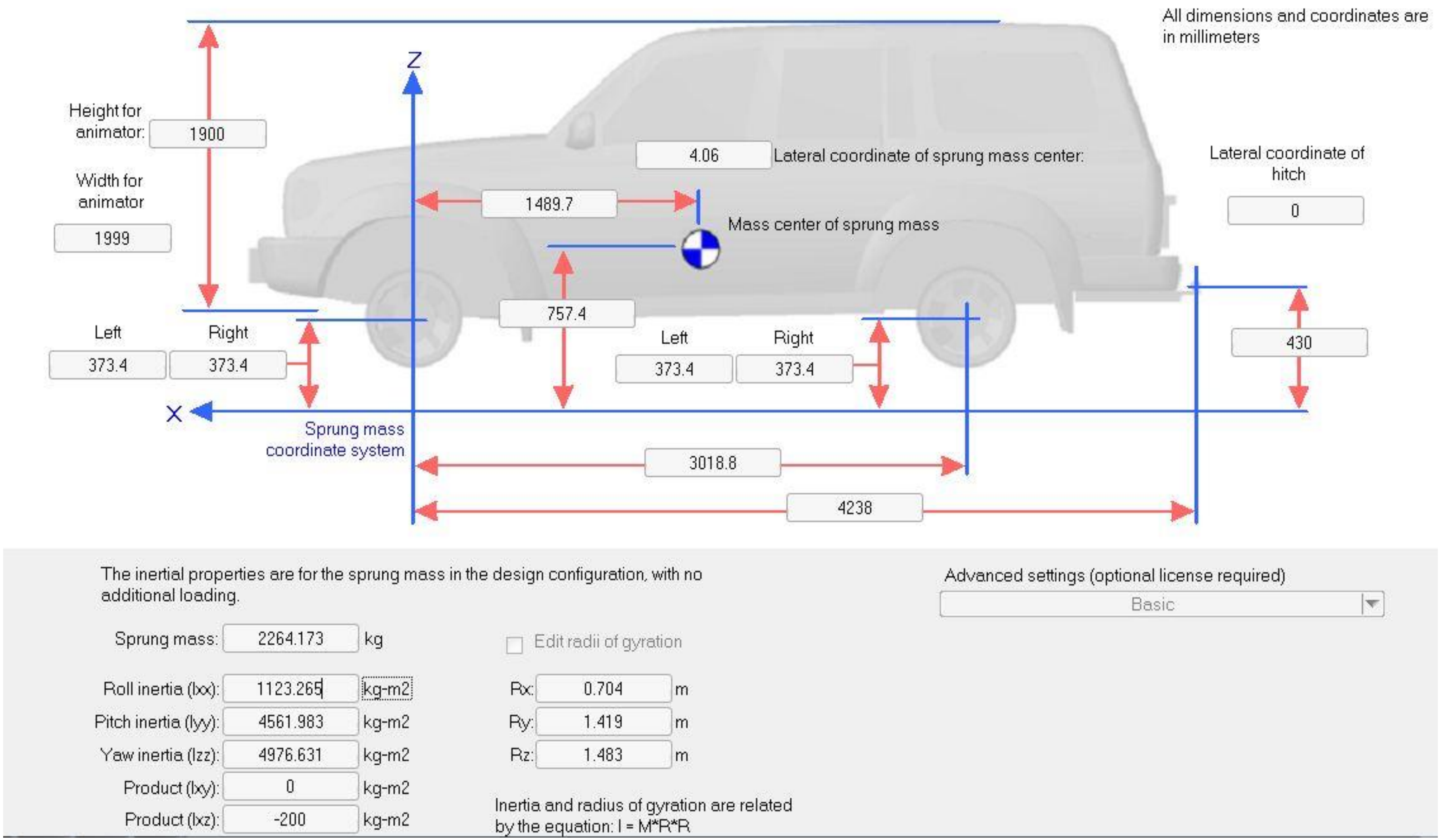
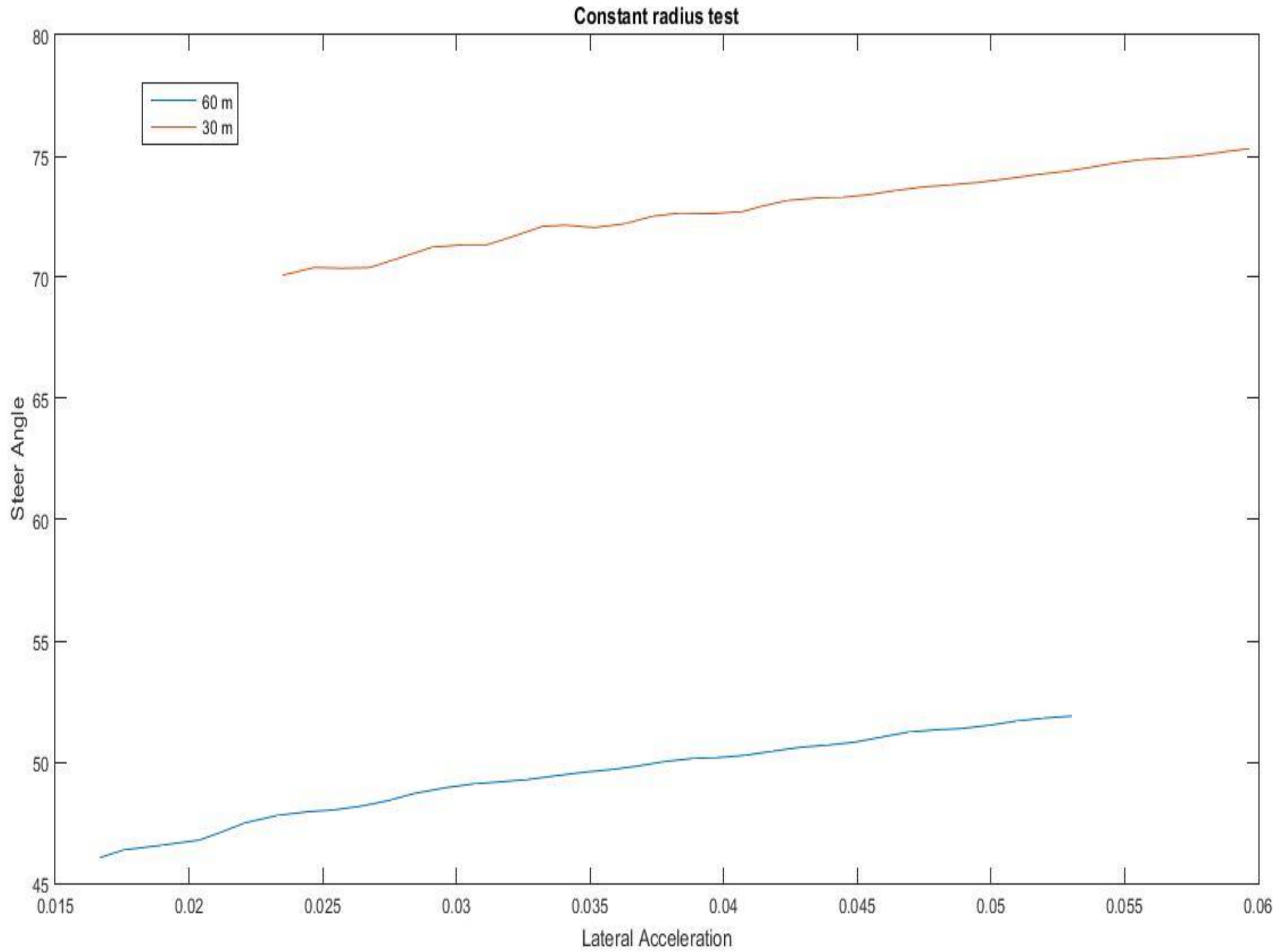
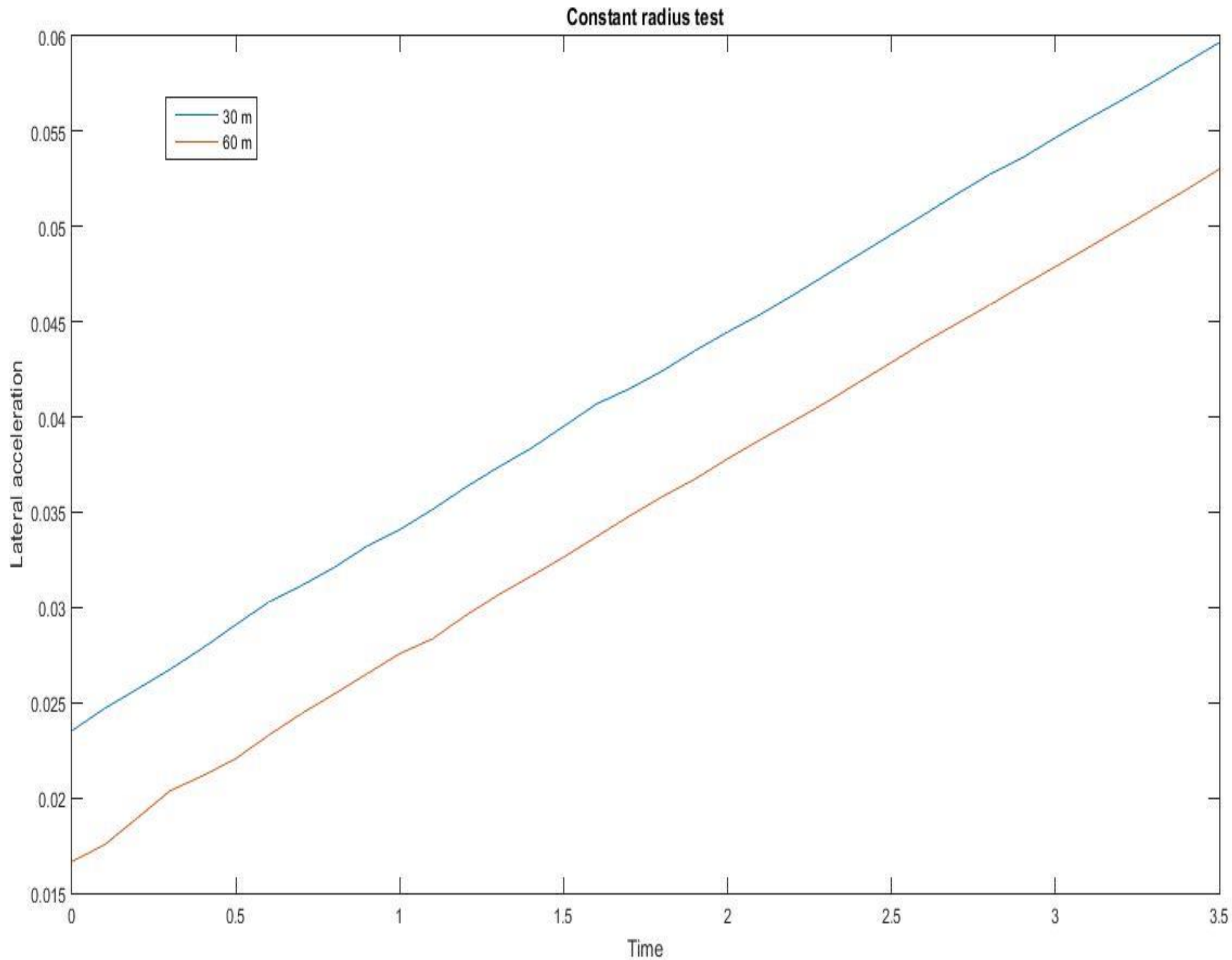


Figure : Vehicle Sprung Mass Model [4]

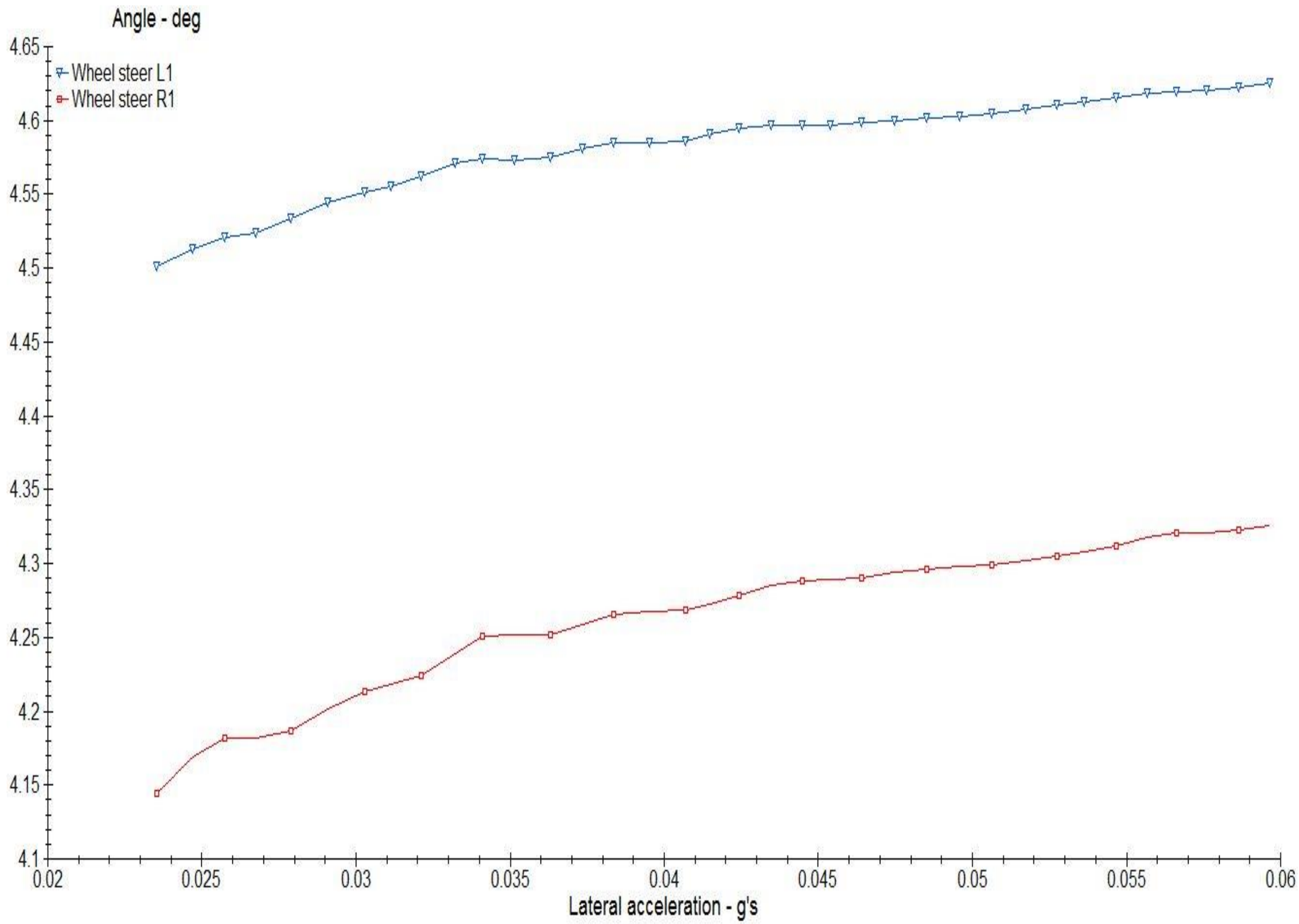
Constant Radius Test: At 60 and 30m, Lateral Acceleration vs. Steer Angle[2&7]



Constant Radius Test: At 60 and 30m, Lateral Acceleration vs. Time[2&7]



Front wheel steering angle vs. Lateral Acceleration[2&7]



Conclusion

- Figure discussed above shows the comparison of lateral acceleration versus time for different radius values. The rate of build up of lateral acceleration is observed to be higher for the smaller radius(30m).
- Lateral acceleration with respect to steer angel for front axle wheels has also been plotted for different radius values. Left wheel (inside one) steers most when we turn left
- The current procedure for executing the constant steer understeer test and the methodology used for calculation of understeer gradient does not take into account the change in the road wheel angles during the course of the test. Hence, there is a need for a better procedure to address this issue. The understeer gradient calculation techniques based on the bicycle model have simplifications and do not take into account the effects of the system compliance.

References

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5. Blue Prints for making Solid Surface Model of car http://carblueprints.info/rus/view/audi/audi-rs4-2005
6. http://www.carsim.com/products/carsim/packages.php#Basic_CarSim
7. Matlab Help Section