MEA49xs : Graduation Project

“Kinematics of Double Wishbone Suspension and Its Visualization”

Supervised by:

Dr. Diaa Abidou

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Presentation Content

- **Objectives**
- **Suspension Hard Points Visualization**
- **Kinematics of Double Wishbone Model**
- **Roll and Pitch Centers**
- **Double Wishbone Model verification by Adams**
- **Double Wishbone Kinematics Motion in 3D Animation**

Objectives

Objectives

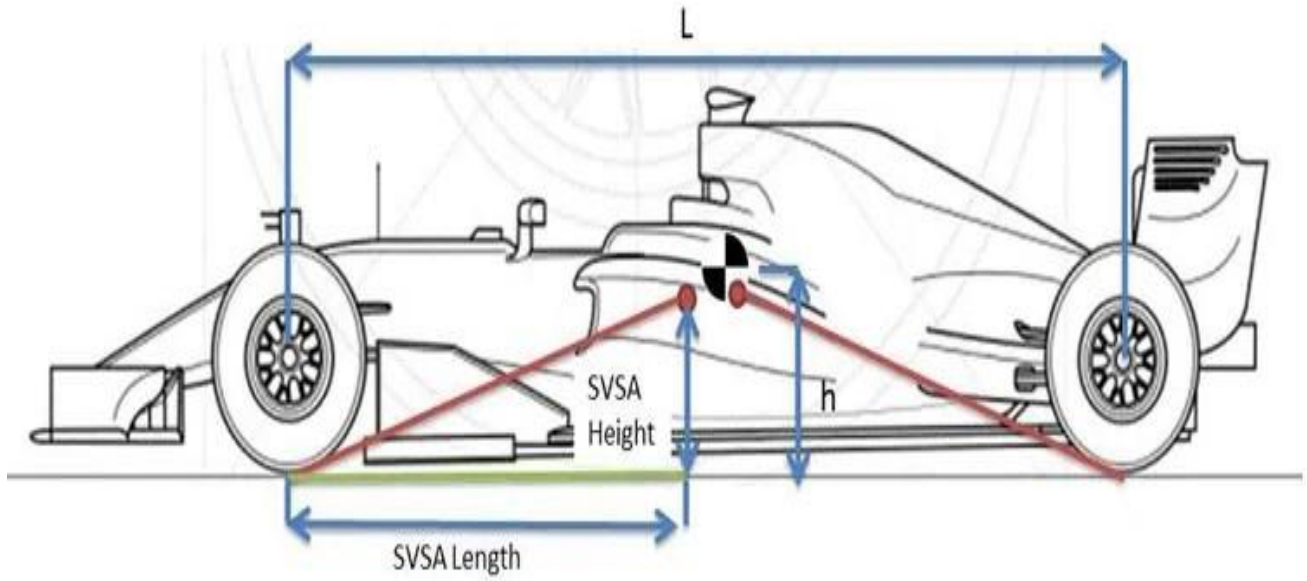
➢ **Simulate double wishbone suspension kinematics and its integration/implementation in vehicle dynamics.**

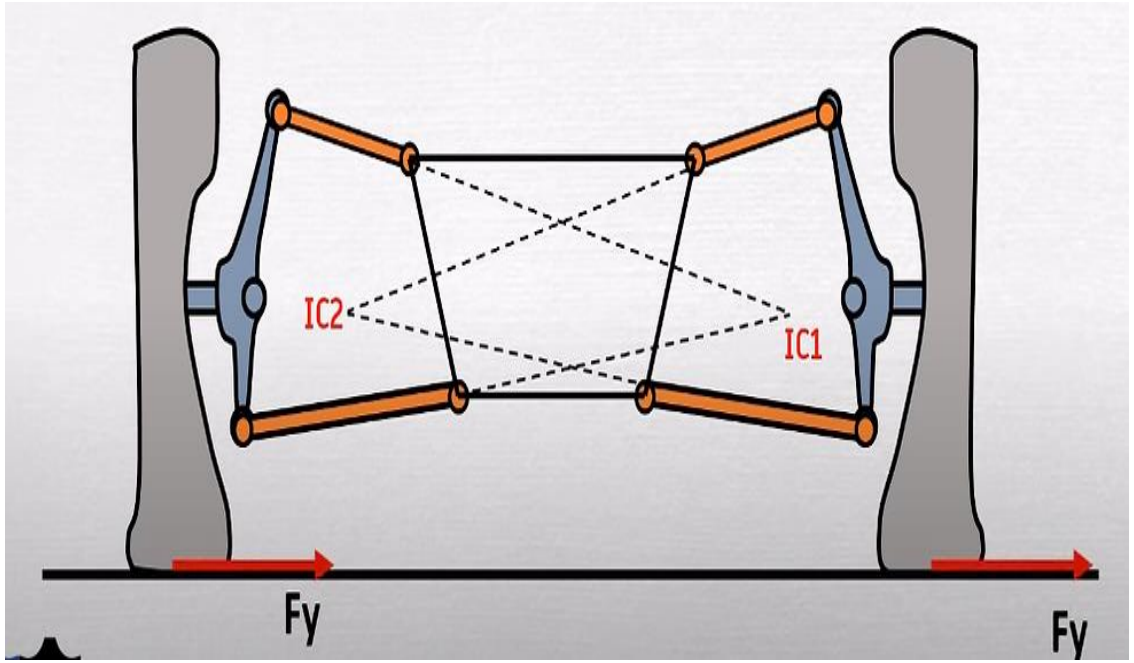
➢ **Visualize double wishbone suspension kinematics motion in a 3D Animation.**

Suspension Hard Points Visualization

Suspension Hard Points Visualization

Key Parameters for Generating Suspension Hard Points

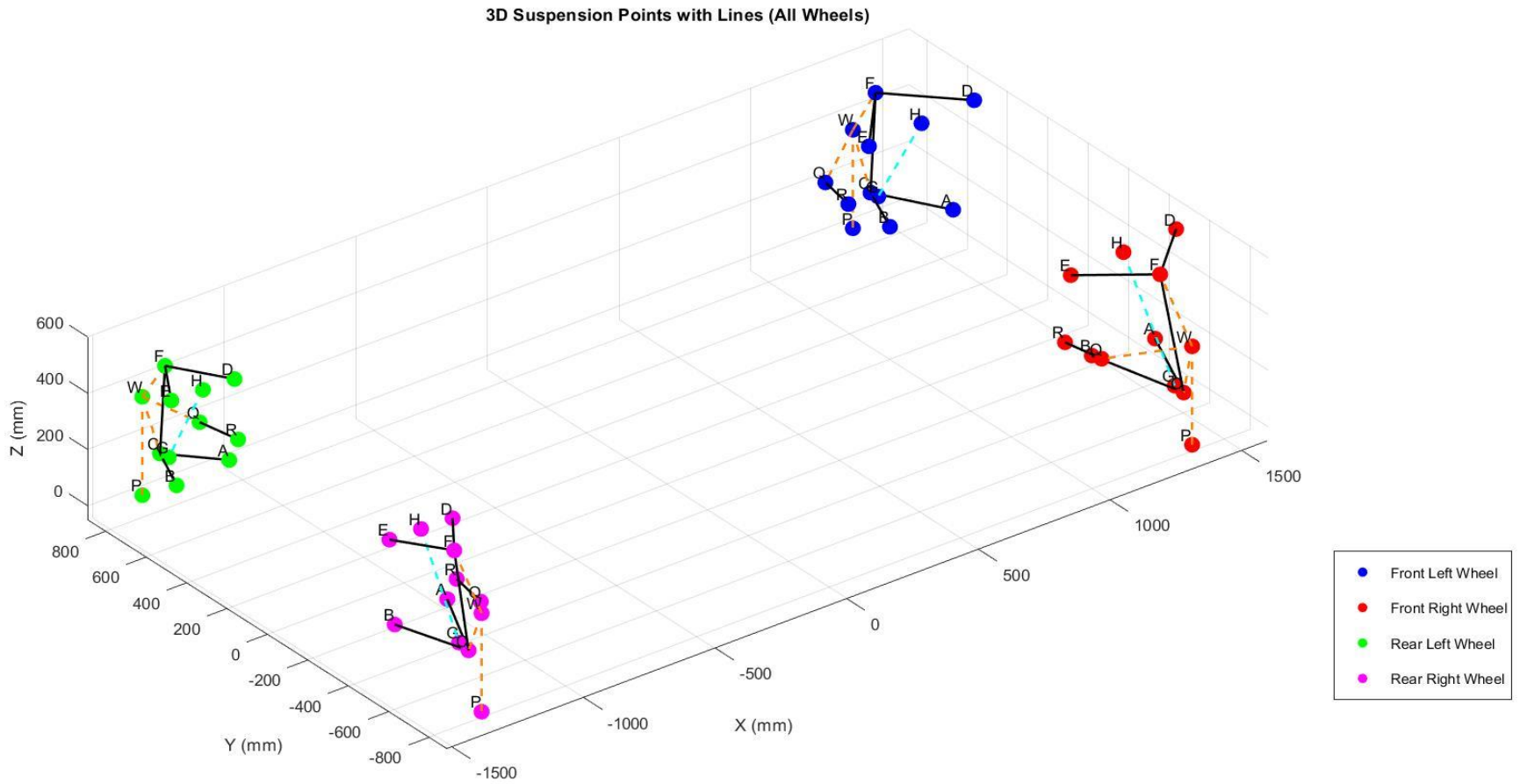




- Images source: **Vatsal Jain** youtube chanel

Suspension Hard Points Visualization

3D Visualization of Suspension Points



Kinematics of Double Wishbone Model

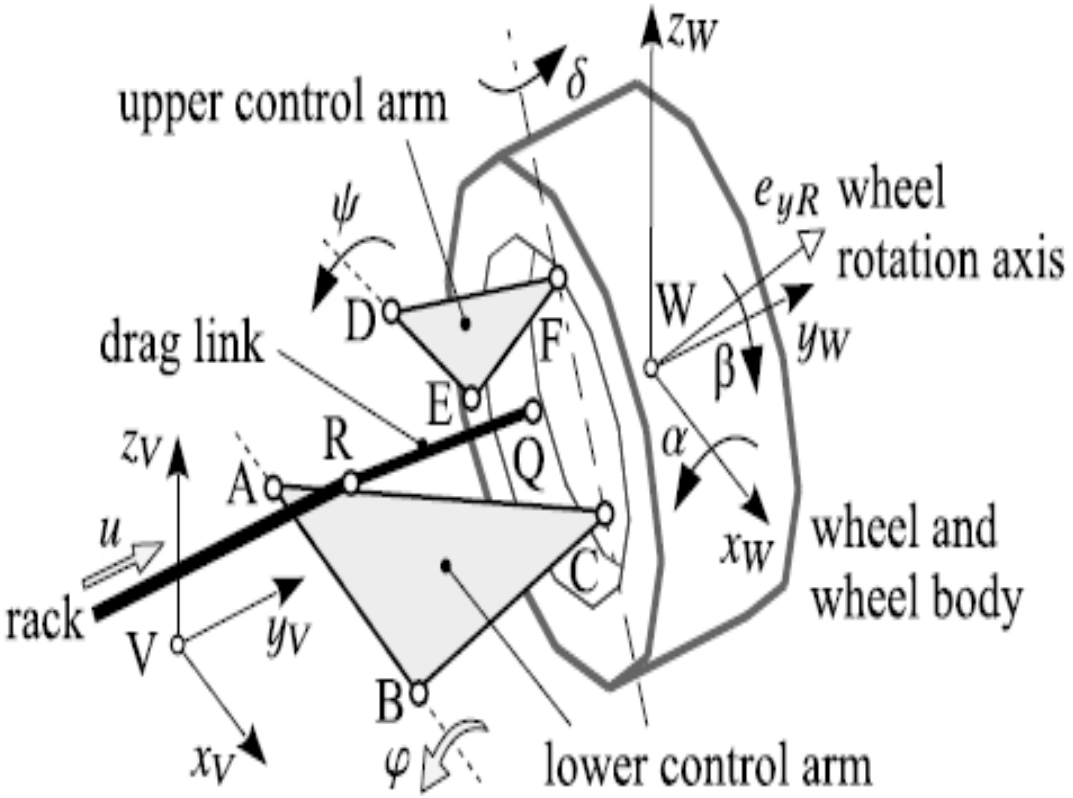
Kinematics of Double Wishbone Model

System Configuration

The system configuration can be determined by two degrees of freedom:

φ: the angle of rotation of lower arm about its fixation axis e_{AB}.

u: the steering rack displacement (y-direction).



- Figure from Georg Rill's **Road Vehicle Dynamics** Textbook

Kinematics of Double Wishbone Model

System Modeling (Equations)

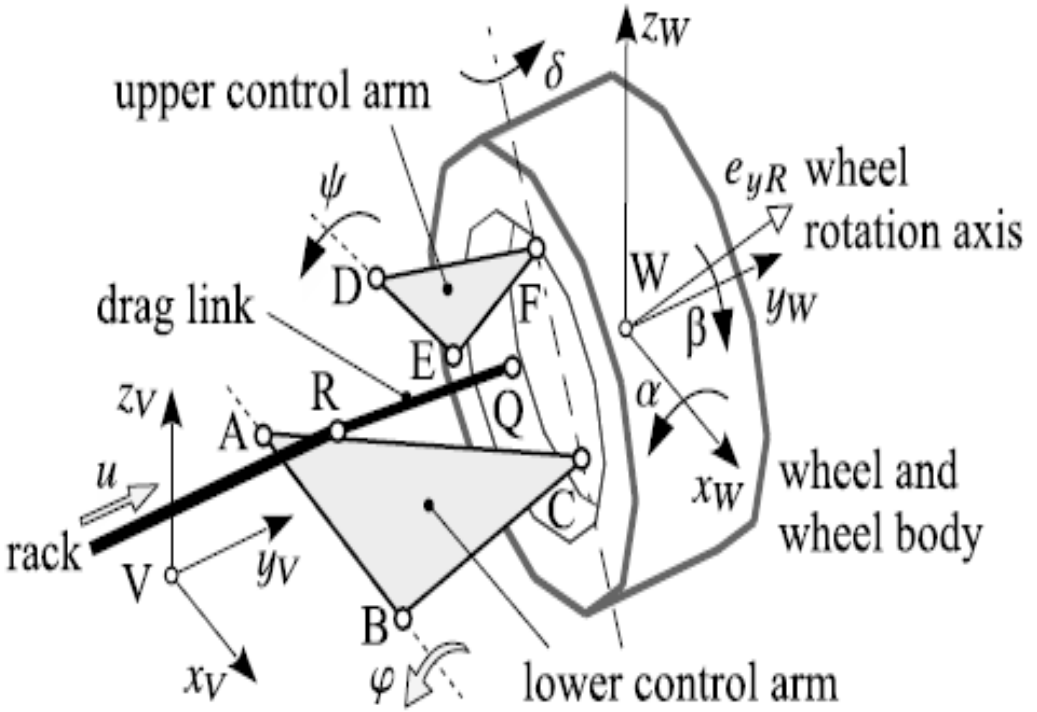
Wheel Center Position (W)

$$\boldsymbol{r_{VW}} = \boldsymbol{r_{VA}} + \boldsymbol{A_{\varphi}}\boldsymbol{r_{AC}} + \boldsymbol{A_{VW}}\boldsymbol{r_{CW}}\,,\ A_{VW} = A_{\alpha}A_{\beta}A_{\delta}$$

$$\alpha = f(\varphi),\ \beta = g(\varphi),\ \delta = h(\varphi, u)$$

Point R Position (R)

$$r_{VR}(u) = r_{VR} + \begin{bmatrix} 0 \\ u \\ 0 \end{bmatrix}$$



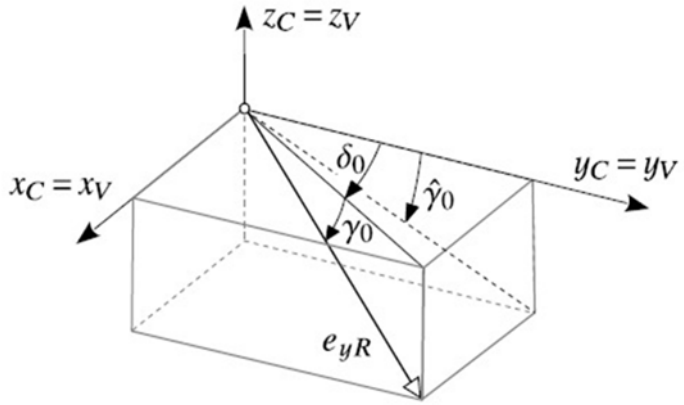
Kinematics of Double Wishbone Model

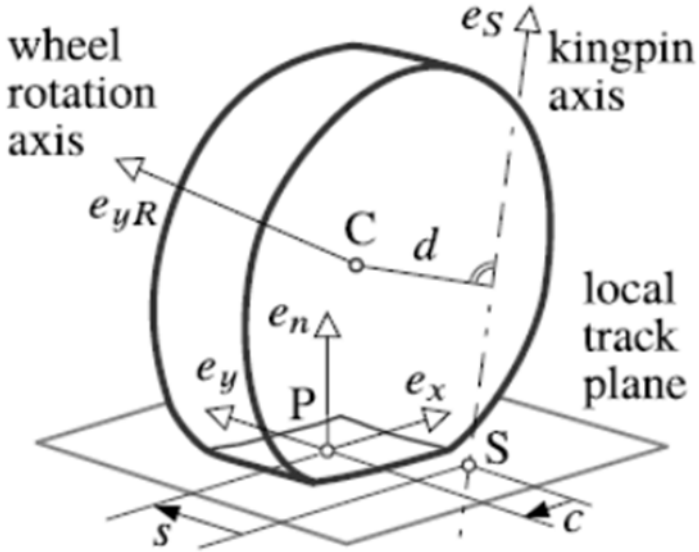
System Modeling (Equations)

Wheel Rotation Axis

$$e_{yR} = \begin{bmatrix} \sin\delta_0 \cos\gamma_0 \\ \cos\delta_0 \cos\gamma_0 \\ -\sin\gamma_0 \end{bmatrix}$$

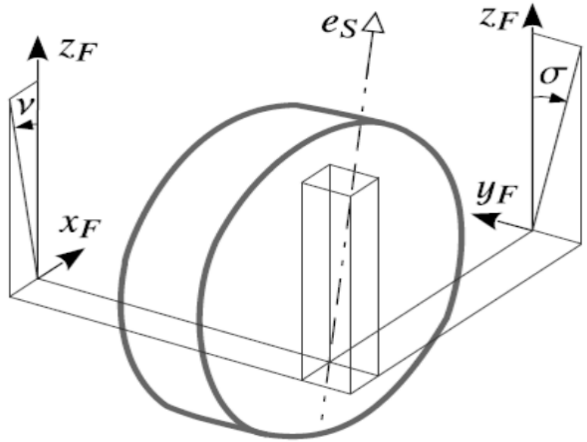
$$e_{yR}(\varphi, u) = A_{VW} e_{yR}$$





Global Wheel Center Position

$$r_{GW} = r_{GV} + A_{GV} r_{VW}$$



- Figures from Georg Rill's **Road Vehicle Dynamics** Textbook

Roll and Pitch Centers

Roll and Pitch Centers

Instant axis in 3D Plane

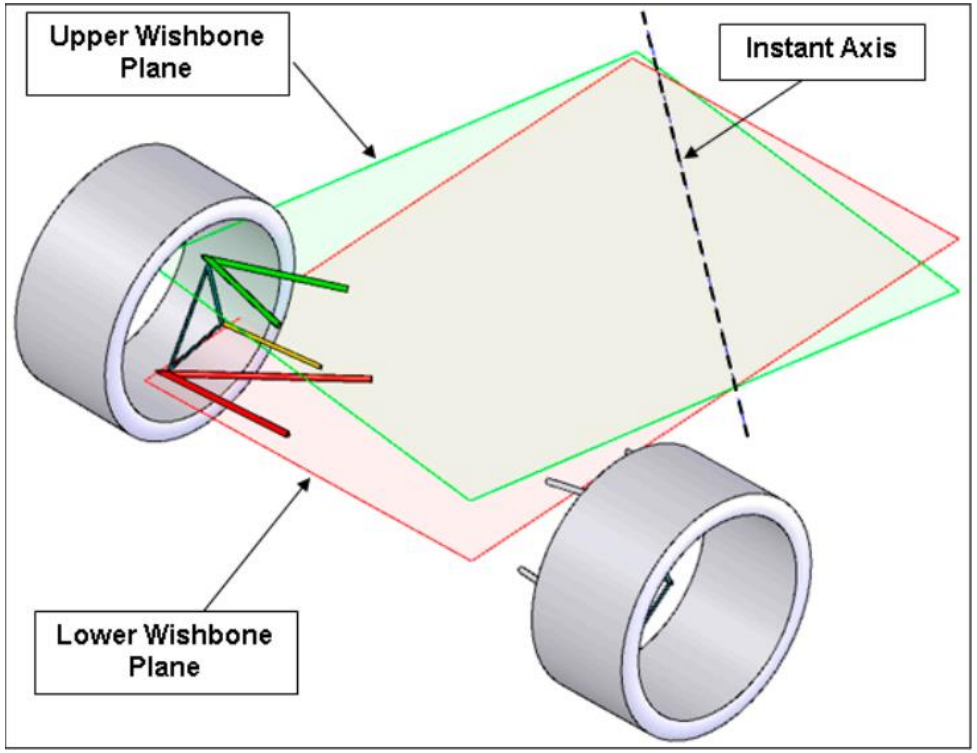
The instant axis is found at the intersection of the planes formed by the upper and lower arms.

Unit Vector of Instantaneous Axis

$$e_{IA} = e_{n,upper\ arm} \times e_{n,lowwer\ arm}$$

Point on Instantaneous Axis

$$r_{arbitrary\ point\ on\ IA} = \begin{bmatrix} e_{n,upper}^T \\ e_{n,lowwer}^T \\ e_{IA}^T \end{bmatrix}^{-1} \begin{bmatrix} e_{n,upper}^T r_F \\ e_{n,lowwer}^T r_C \\ e_{IA}^T r_P \end{bmatrix}$$



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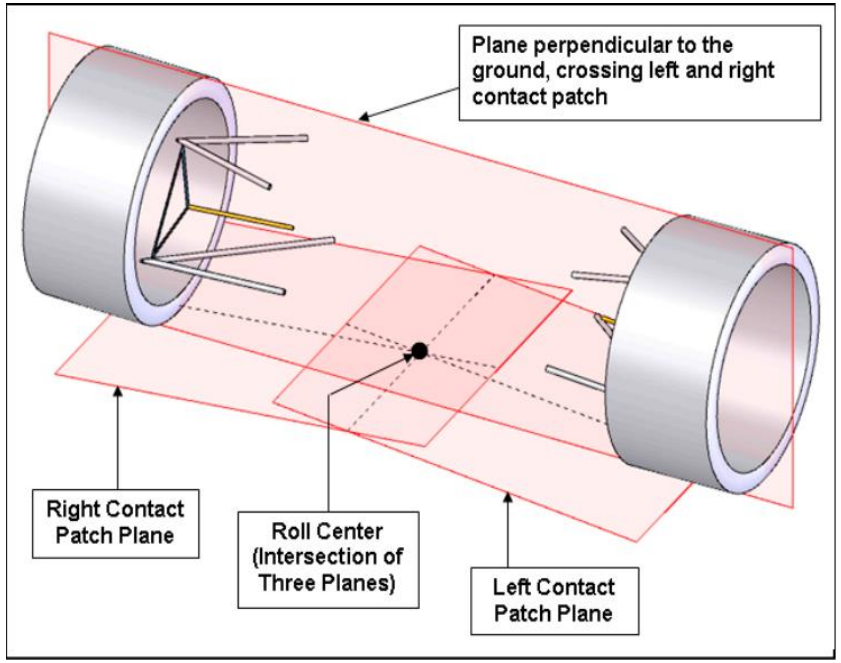
Roll and Pitch Centers

Roll Center in 3D Plane



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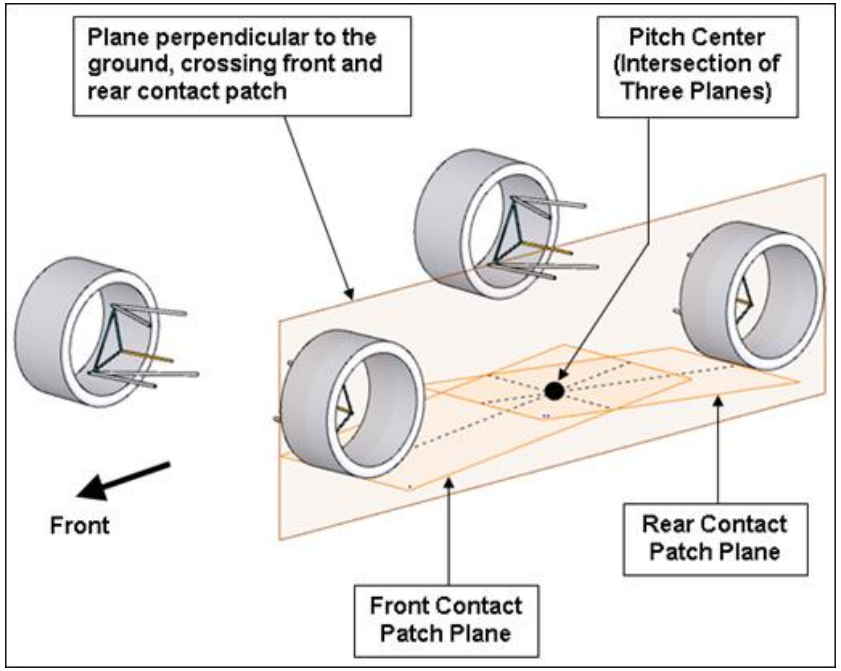
Pitch Center in 3D Plane



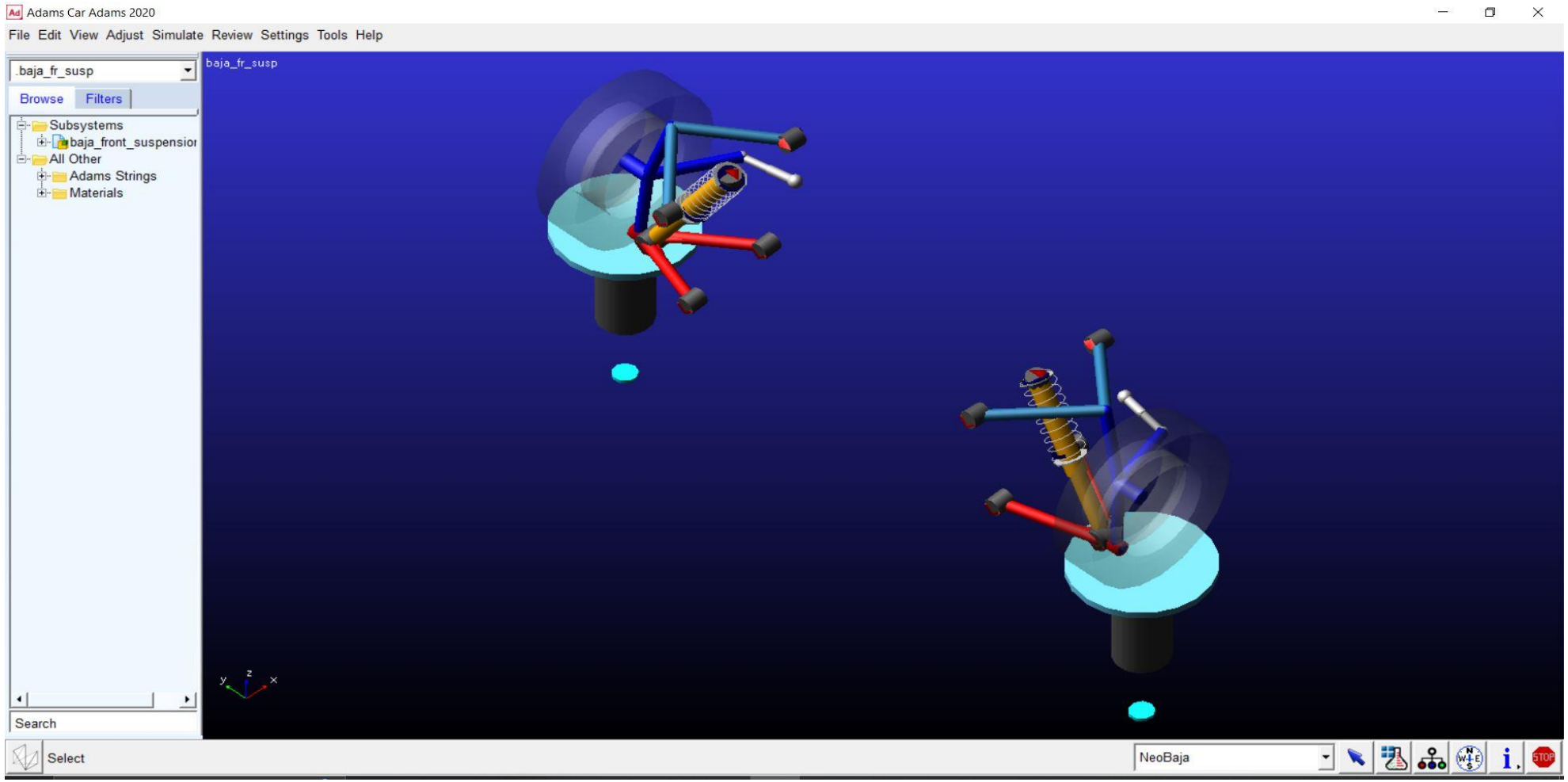
[1]

[1]: Mohan, G., Rouelle, C., & Hugon, E. (n.d.). A New Method to Evaluate Bump Steer and Steering Influence on Kinematic Roll and Pitch Axes for All Independent Suspension Types.(SAE Technical Paper)

Double Wishbone Model verification by Adams

Double Wishbone Model verification by Adams

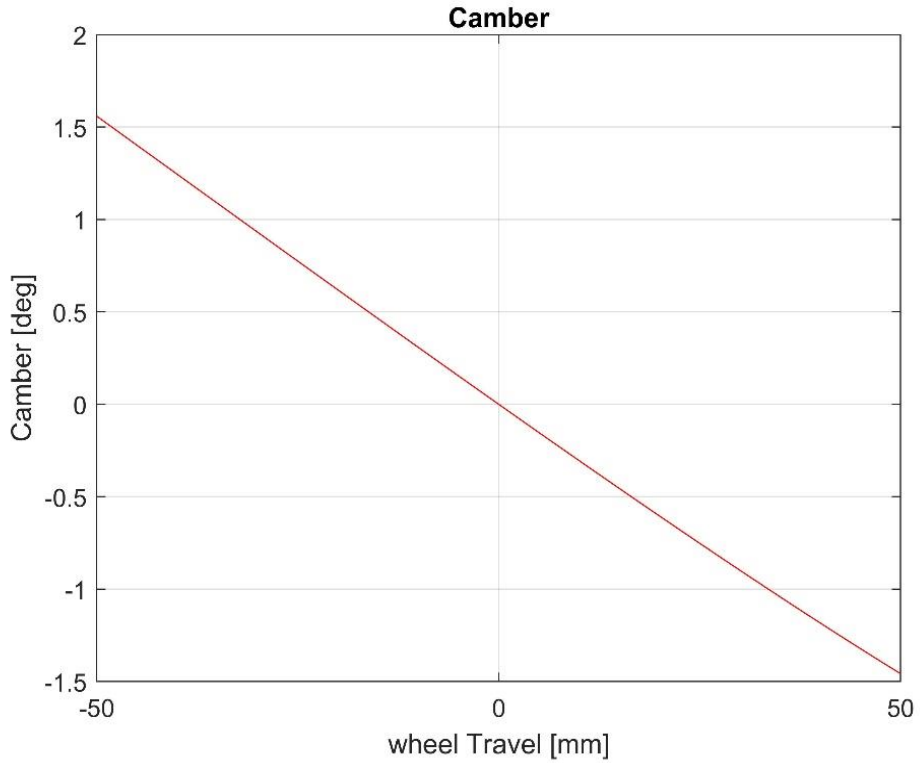
3D Model of Double Wishbone Suspension in Adams



Double Wishbone Model verification by Adams

Parallel Travel Scenario (no steering): Camber Angle

- **Kinematics Model**

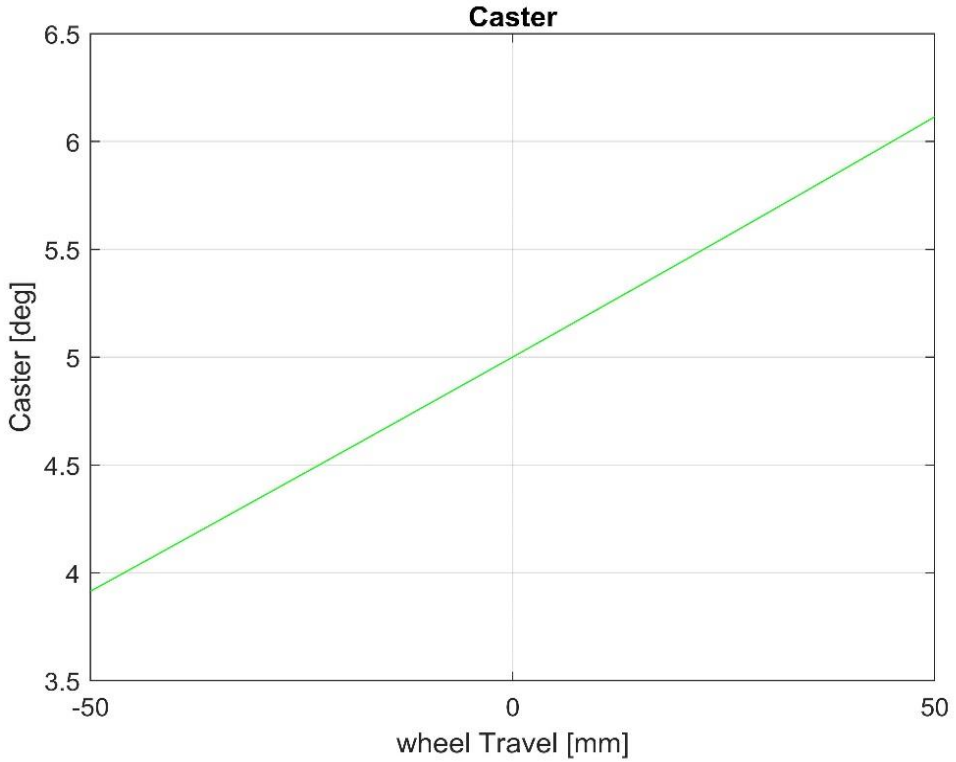


- **Adams Model**

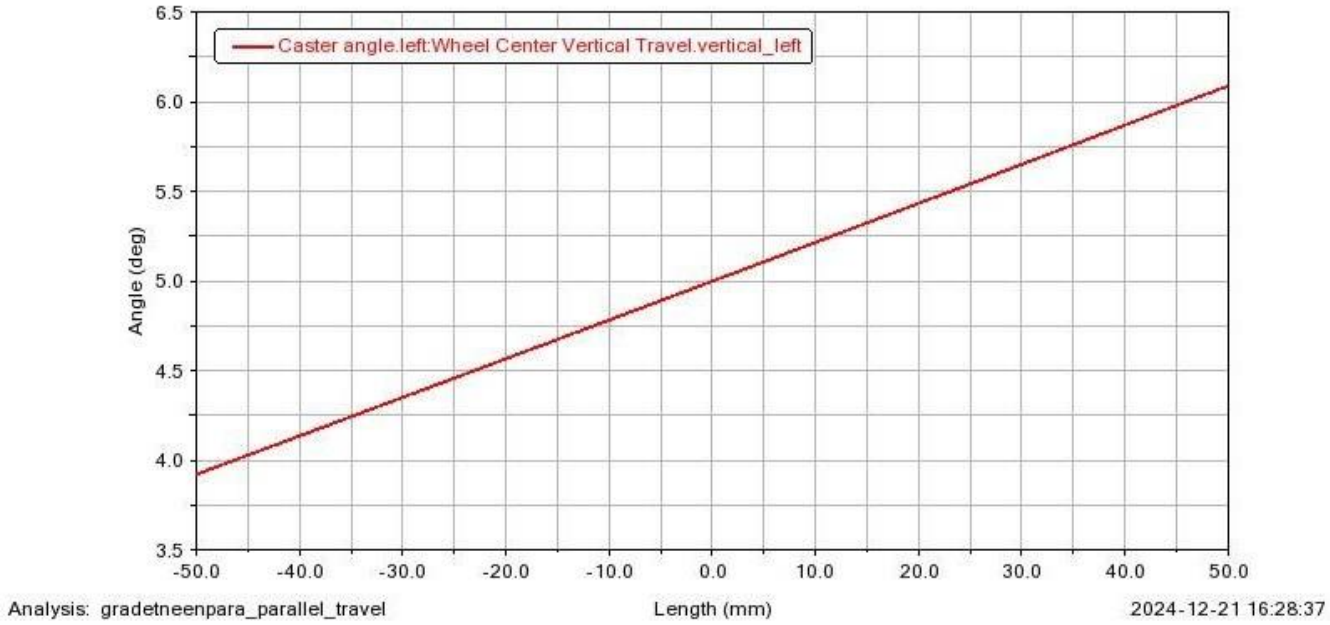
Double Wishbone Model verification by Adams

Parallel Travel Scenario (no steering): Caster Angle

- **Kinematics Model**



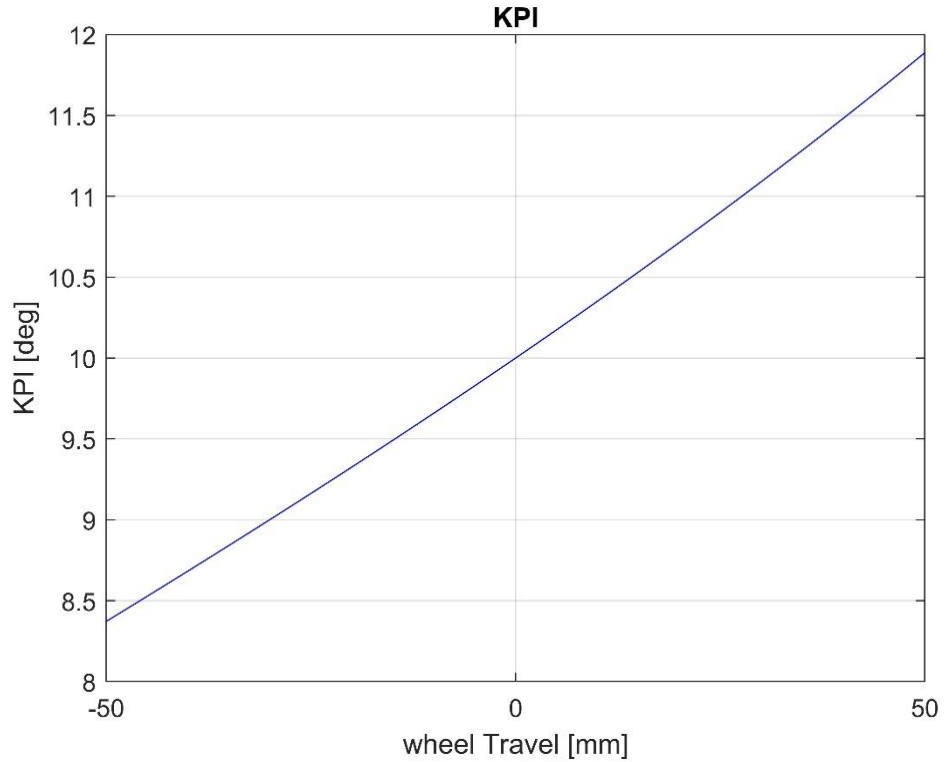
- **Adams Model**



Double Wishbone Model verification by Adams

Parallel Travel Scenario (no steering): KPI Angle

- **Kinematics Model**

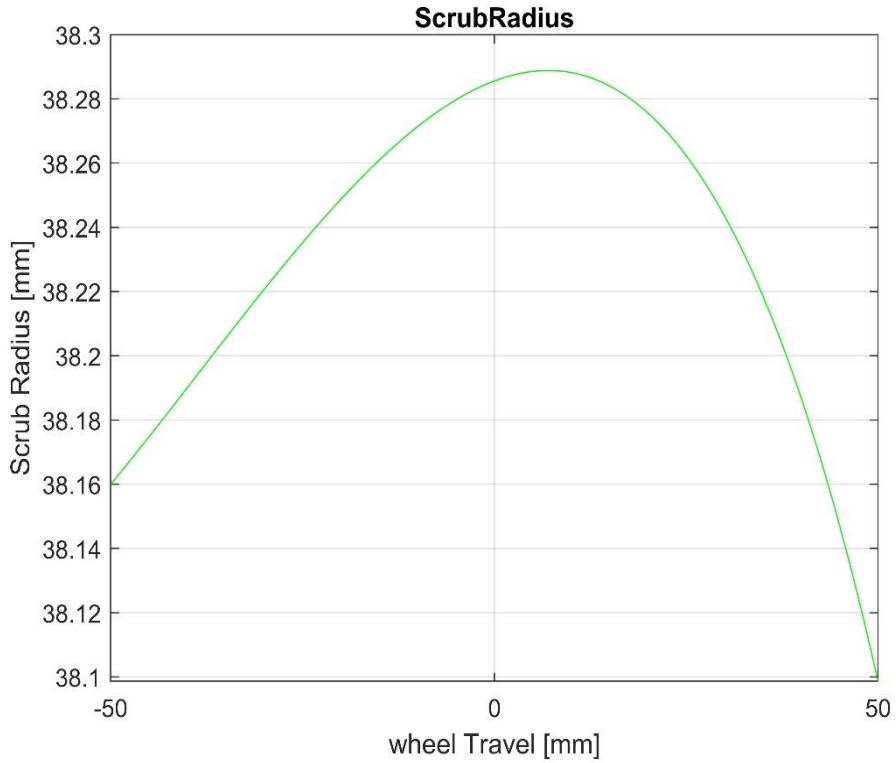


- **Adams Model**

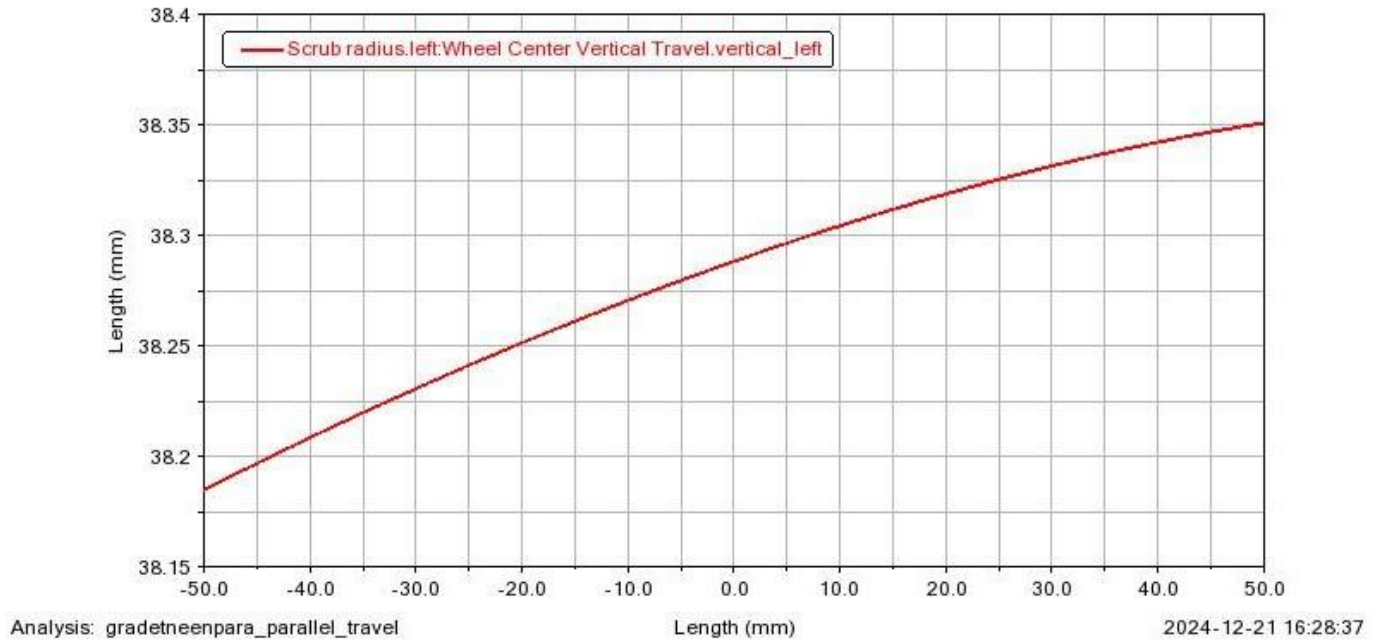
Double Wishbone Model verification by Adams

Parallel Travel Scenario (no steering): Scrub Radius

- **Kinematics Model**



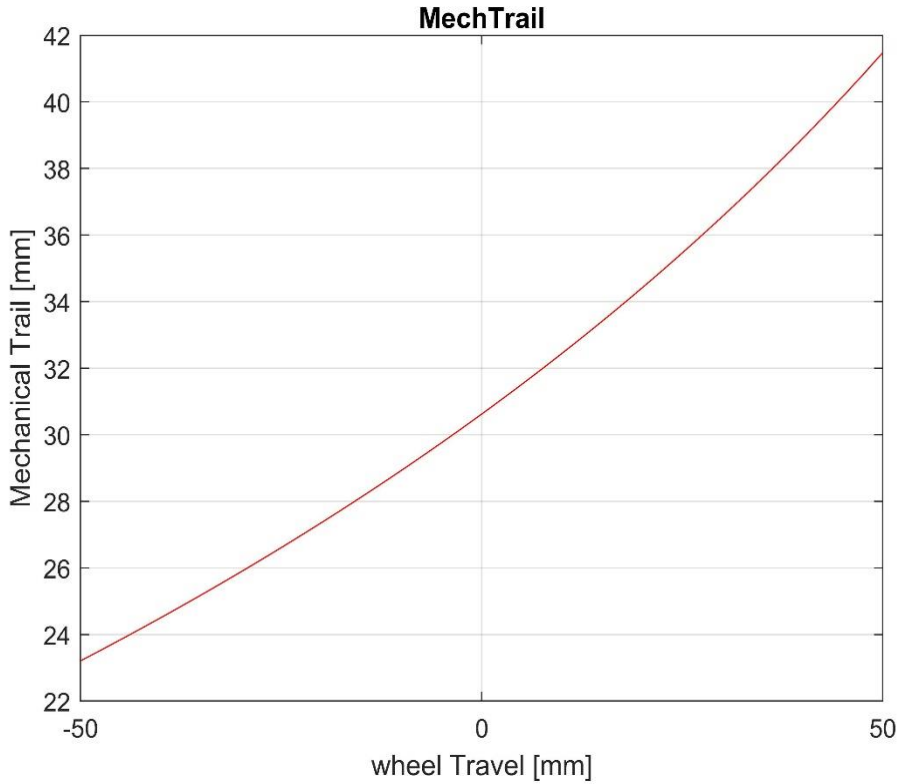
- **Adams Model**



Double Wishbone Model verification by Adams

Parallel Travel Scenario (no steering): Mechanical Trail

- **Kinematics Model**

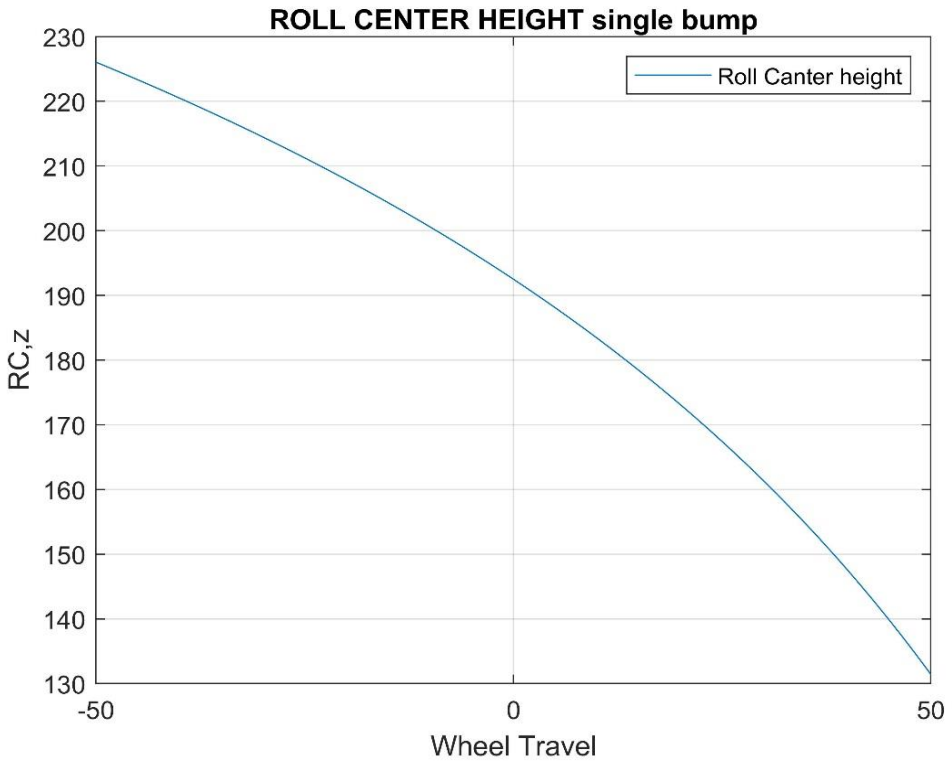


- **Adams Model**

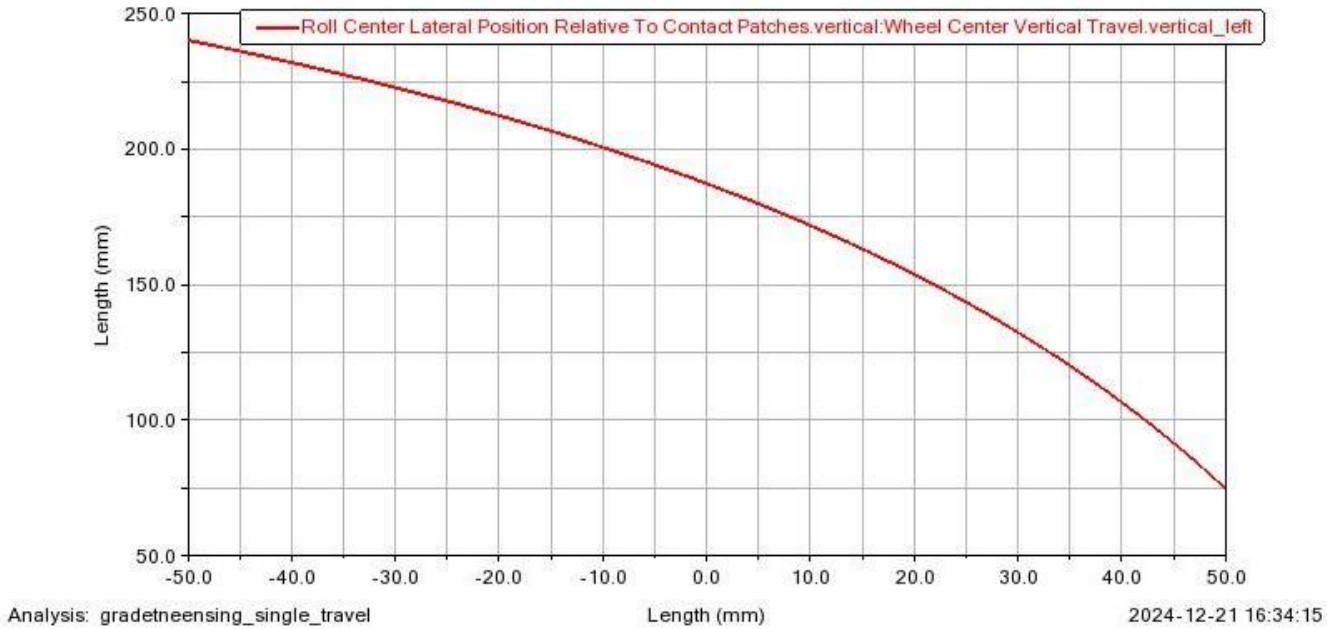
Double Wishbone Model verification by Adams

Single Travel Scenario (no steering): Roll Center Height

- **Kinematics Model**



- **Adams Model**



Double Wishbone Model verification by Adams

- **Results Discussion**

- **Adams tire Model.**
- **Elasticity in links and joints.**
- **Trials, error and approximations.**

Kinematics Model Extra Results

Wheel center and contact patch point's paths in front and side views

- **Kinematics Model**