



Development & Validation of a Generic 3-D Vehicle Model & GUI for Studying the Handling Performance

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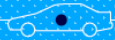
*Crashport
Huntsville, AL, 35806*



Motivation

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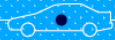
- As product complexity increases, hardware prototyping becomes more costly and less feasible to accomplish.
- Virtual prototyping has become increasingly important
 - To reduce the cost and time associated with hardware prototype
 - To experiment with innovative design variations earlier in the design cycle



Objective

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- To present a 3D vehicle dynamics model including a simple suspension system to study the handling performance of vehicles
- To develop a Graphical User Interface to facilitate the change of the design parameters.
- To provide some validation data



Outline

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- Motivation ✓
- Objective ✓
 - To present a 3D vehicle model to study handling performance

• Model & GUI Description

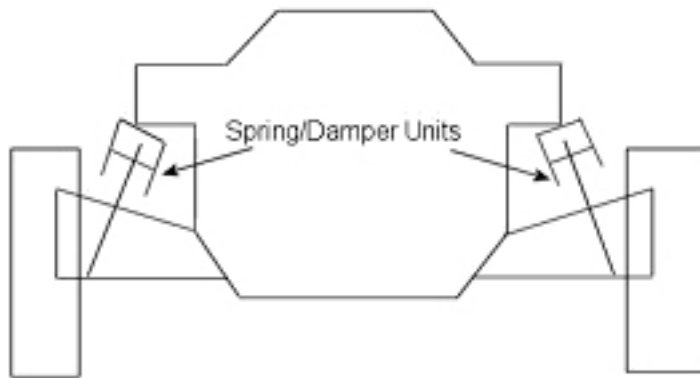
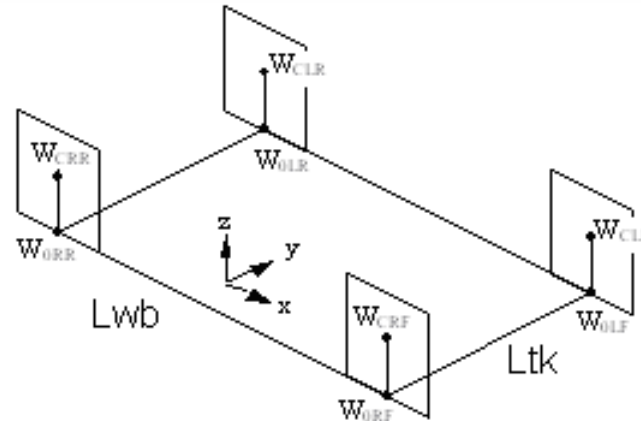
- Case Studies
 - MSC.ADAMS versus CarSIM Educational
 - MSC.ADAMS versus NADS
- Conclusions



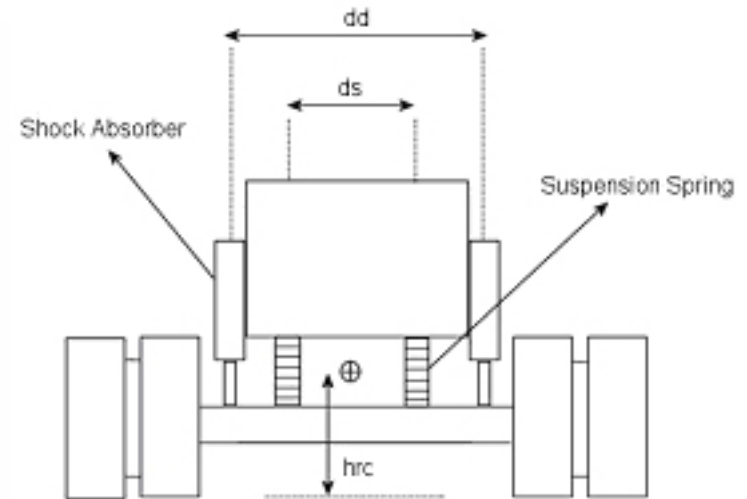
Model Description

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Rigid Bodies



Independent Suspension



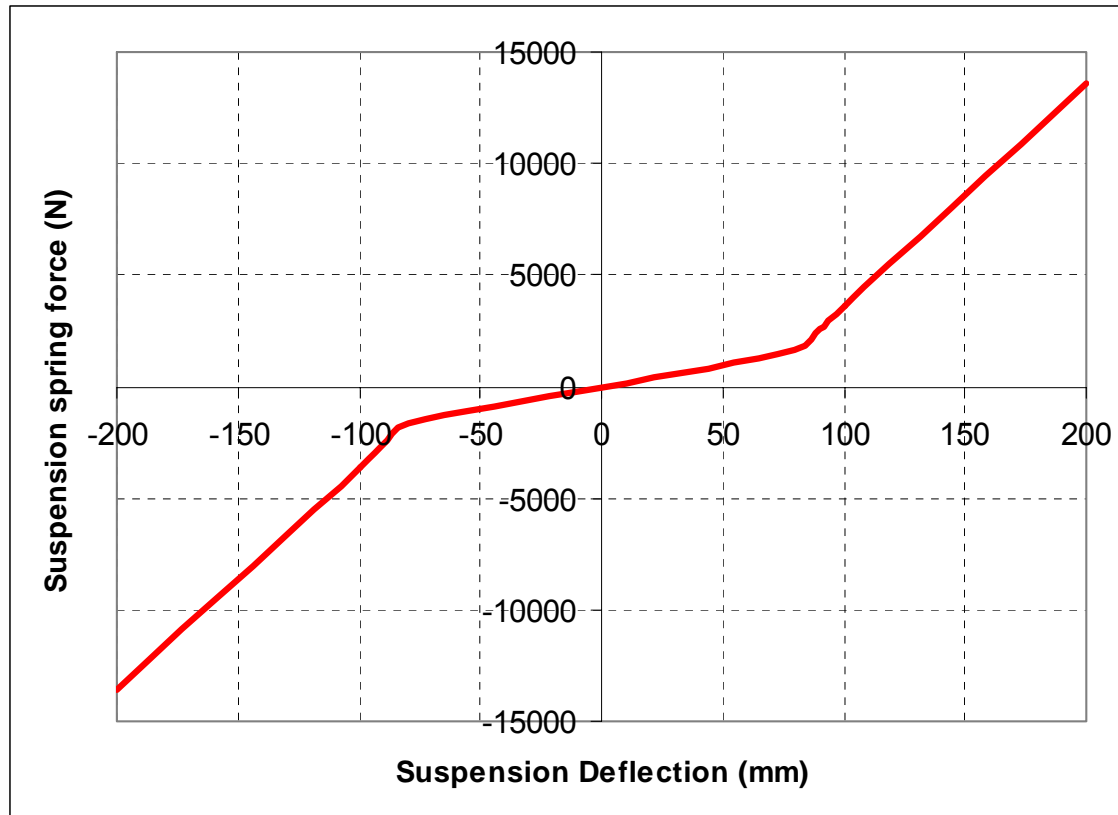
Solid Axle Suspension

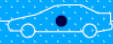
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Suspension Force Deflection Characteristics

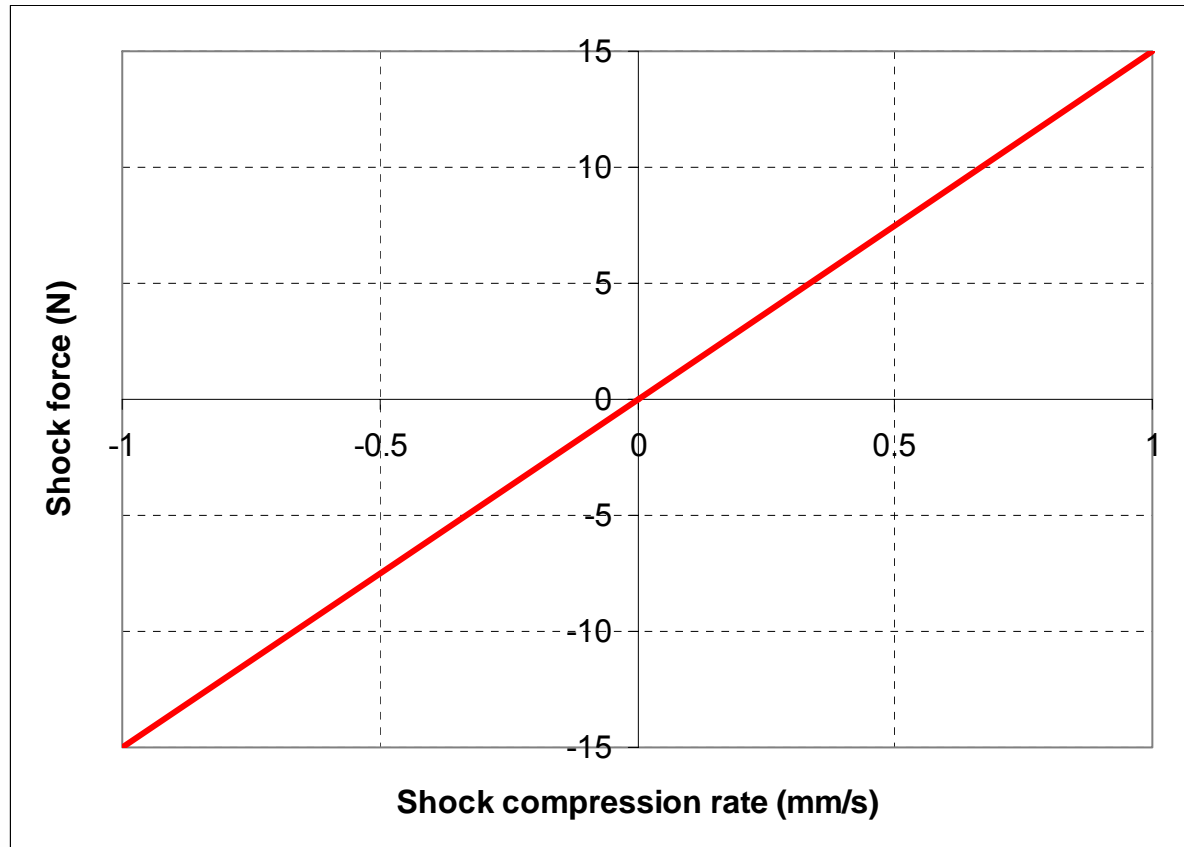
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Suspension Shock Absorber Characteristics

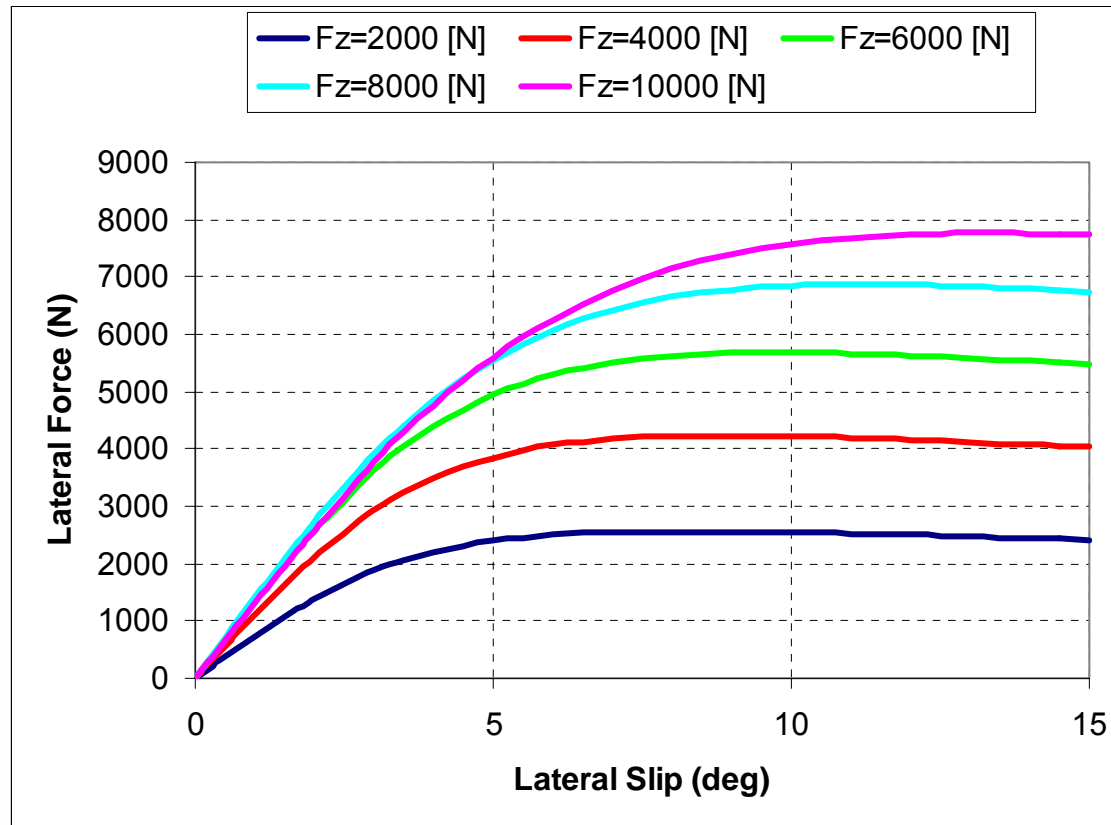
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Lateral Tire Force versus Slip Angle

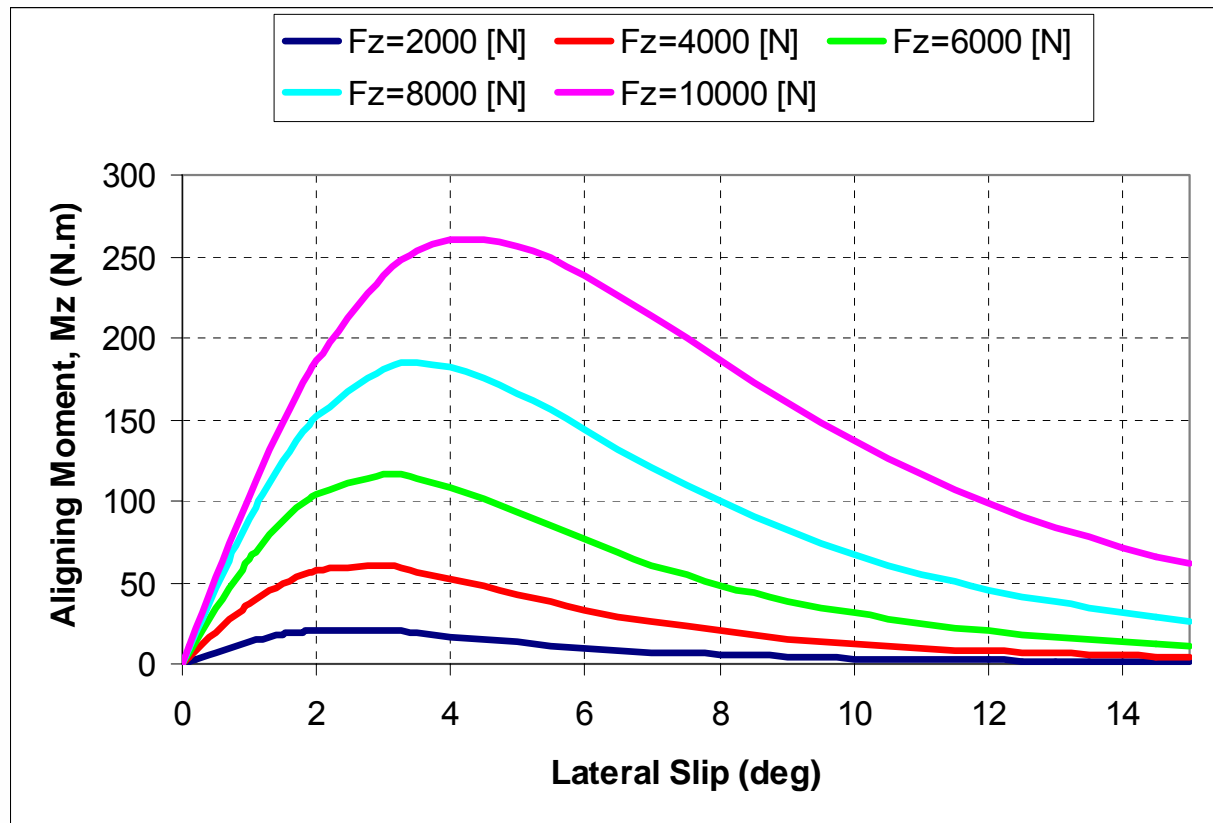
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Aligning Moment versus Slip Angle

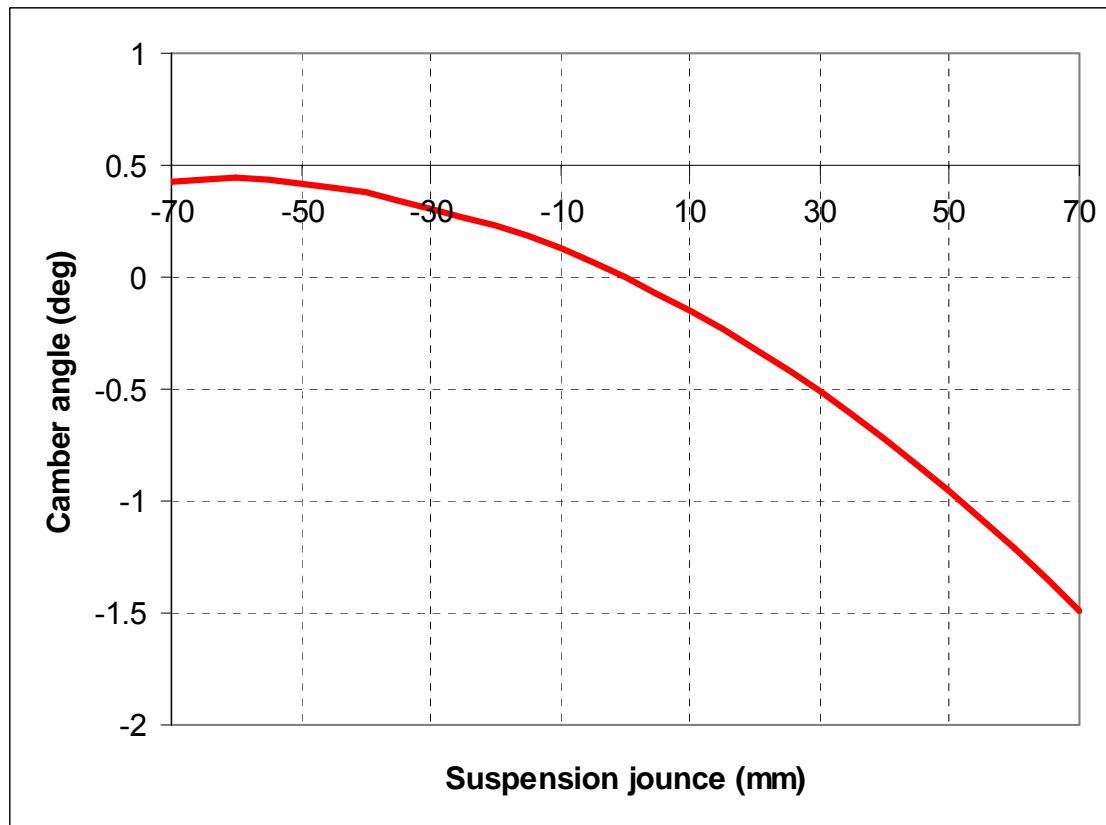
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Camber Angle versus Suspension Jounce

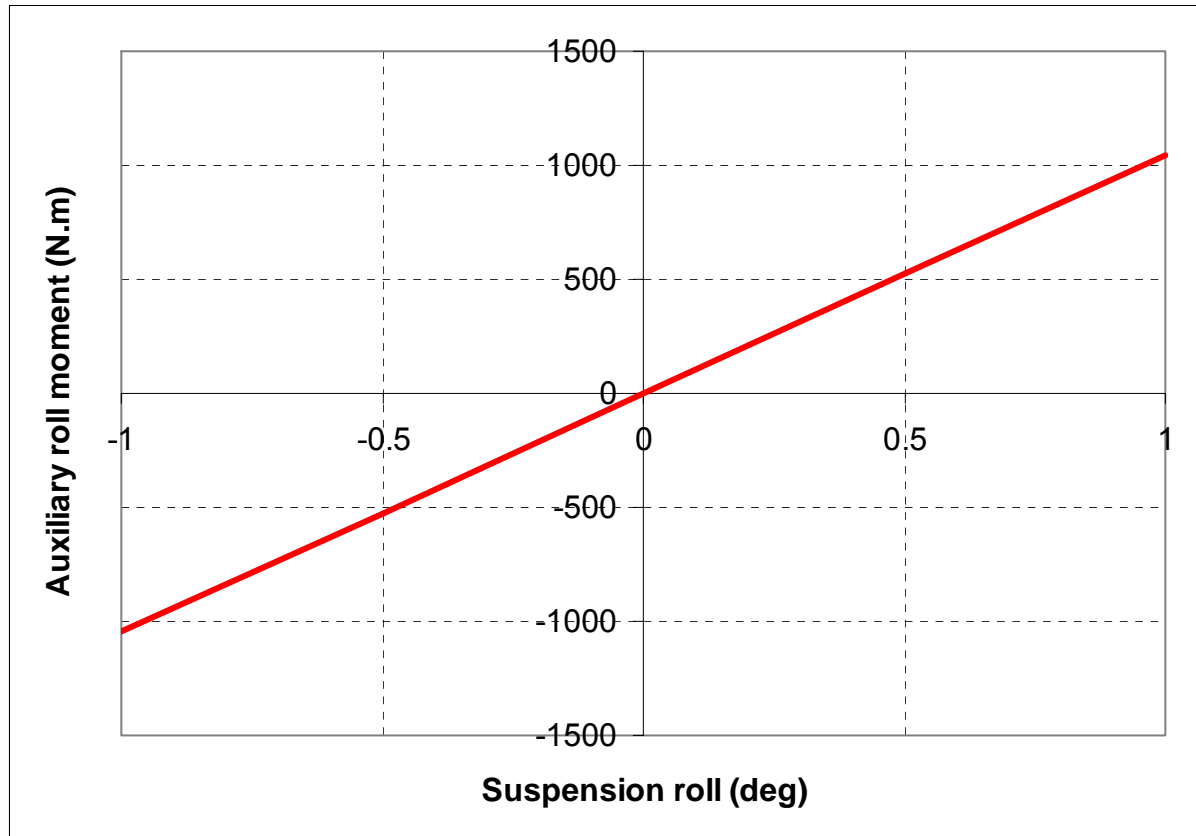
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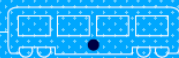




Auxiliary Roll Moment versus Roll Angle

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GUI Description

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Vehicle_Parameters

VEHICLE PARAMETERS TOOLBOX

| | | | |
|--|----------------------|--|----------------------|
| Vehicle mass supported by the front axle | <input type="text"/> | Front damper rate @ shock absorber | <input type="text"/> |
| Vehicle mass supported by rear axle | <input type="text"/> | Nominal height of the front axle roll center | <input type="text"/> |
| Front axle unsprung mass | <input type="text"/> | Nominal height of the rear axle roll center | <input type="text"/> |
| Rear axle unsprung mass | <input type="text"/> | Front axle shock absorber spacing | <input type="text"/> |
| Front axle track width | <input type="text"/> | Wheelbase change/jounce @ rear | <input type="text"/> |
| Rear axle track width | <input type="text"/> | Rear axle suspension spacing | <input type="text"/> |
| Nominal height of the vehicle | <input type="text"/> | Tire Cornering Stiffness | <input type="text"/> |
| Undeformed front wheel center height | <input type="text"/> | Rear axle shock absorber spacing | <input type="text"/> |
| Undeformed rear wheel center height | <input type="text"/> | Wheelbase change/jounce @ front axle | <input type="text"/> |
| Moment of Inertia of the Vehicle in X | <input type="text"/> | Front axle suspension spacing | <input type="text"/> |
| Moment of Inertia of the Vehicle in Y | <input type="text"/> | Rear tire vertical stiffness | <input type="text"/> |
| Moment of Inertia of the Vehicle in Z | <input type="text"/> | Front tire vertical stiffness | <input type="text"/> |
| Moment of Inertia of the Vehicle in XZ | <input type="text"/> | Rear suspension spring stiffness | <input type="text"/> |
| Wheelbase | <input type="text"/> | Front suspension spring stiffness | <input type="text"/> |
| Vehicle speed | <input type="text"/> | Rear damper rate @ shock absorber | <input type="text"/> |

3D_Vehicle_Model_Toolbox

Load the Vehicle Parameters

Vehicle Chassis (Single Unit Vehicle)

Front Axle Model

Independent_Suspension

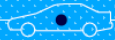
Update

Rear Axle Model

Independent_Suspension

Update

Delete the Model



Outline

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- Motivation ✓
- Objective ✓
 - To present a 3D vehicle model to study handling performance
- Model & GUI Description ✓

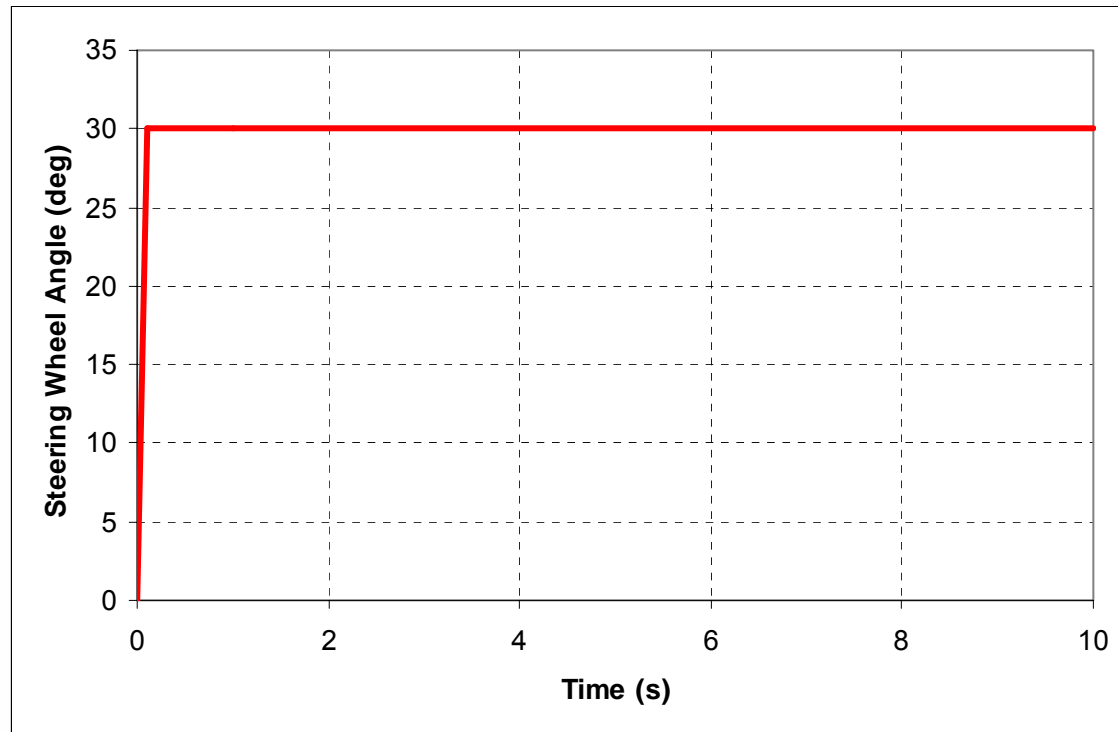
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- Conclusions



Step Steer: CarSIM versus MSC.ADAMS

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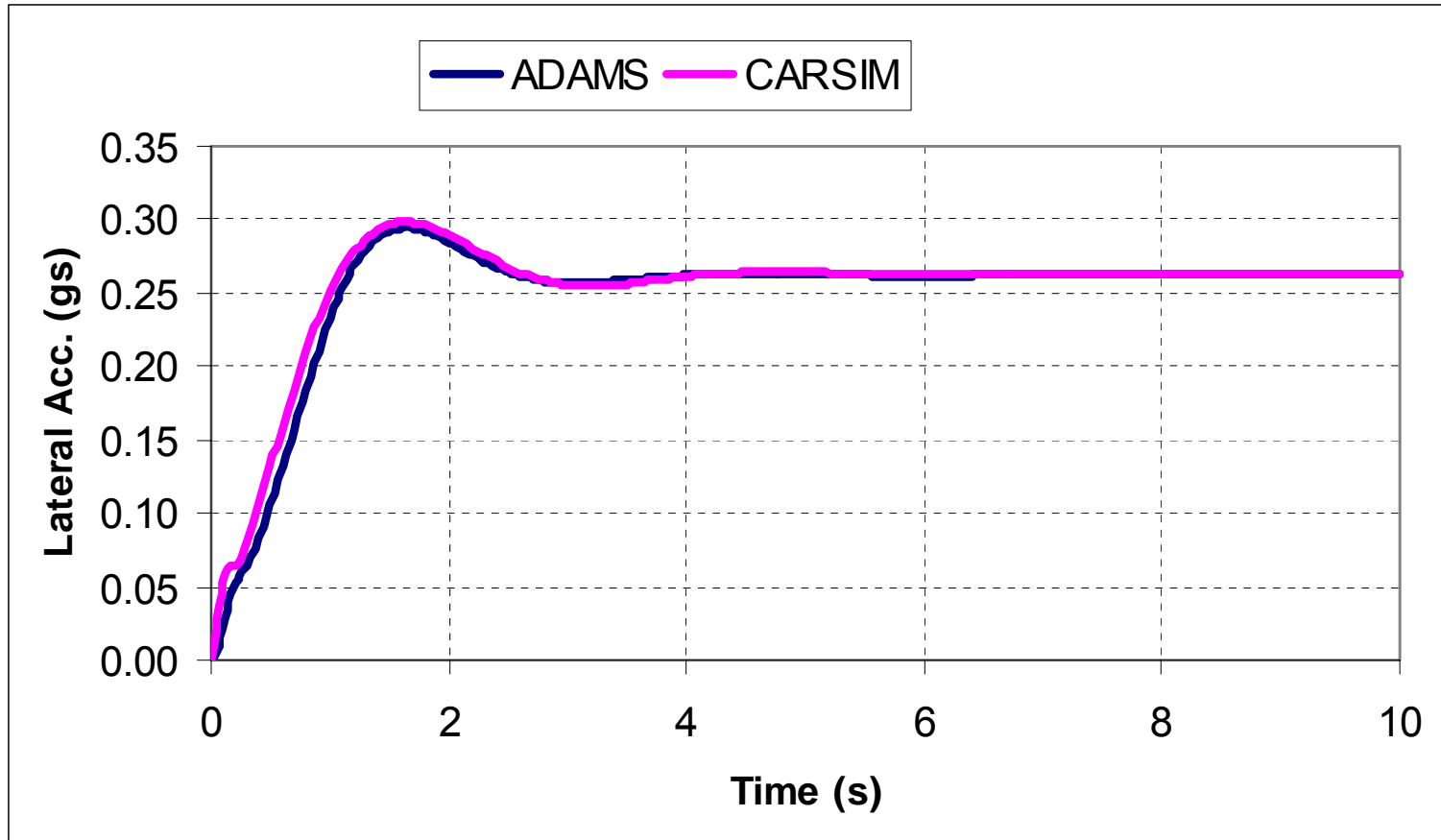


Vehicle speed is set to 100 kph.



Results - Lateral Acceleration

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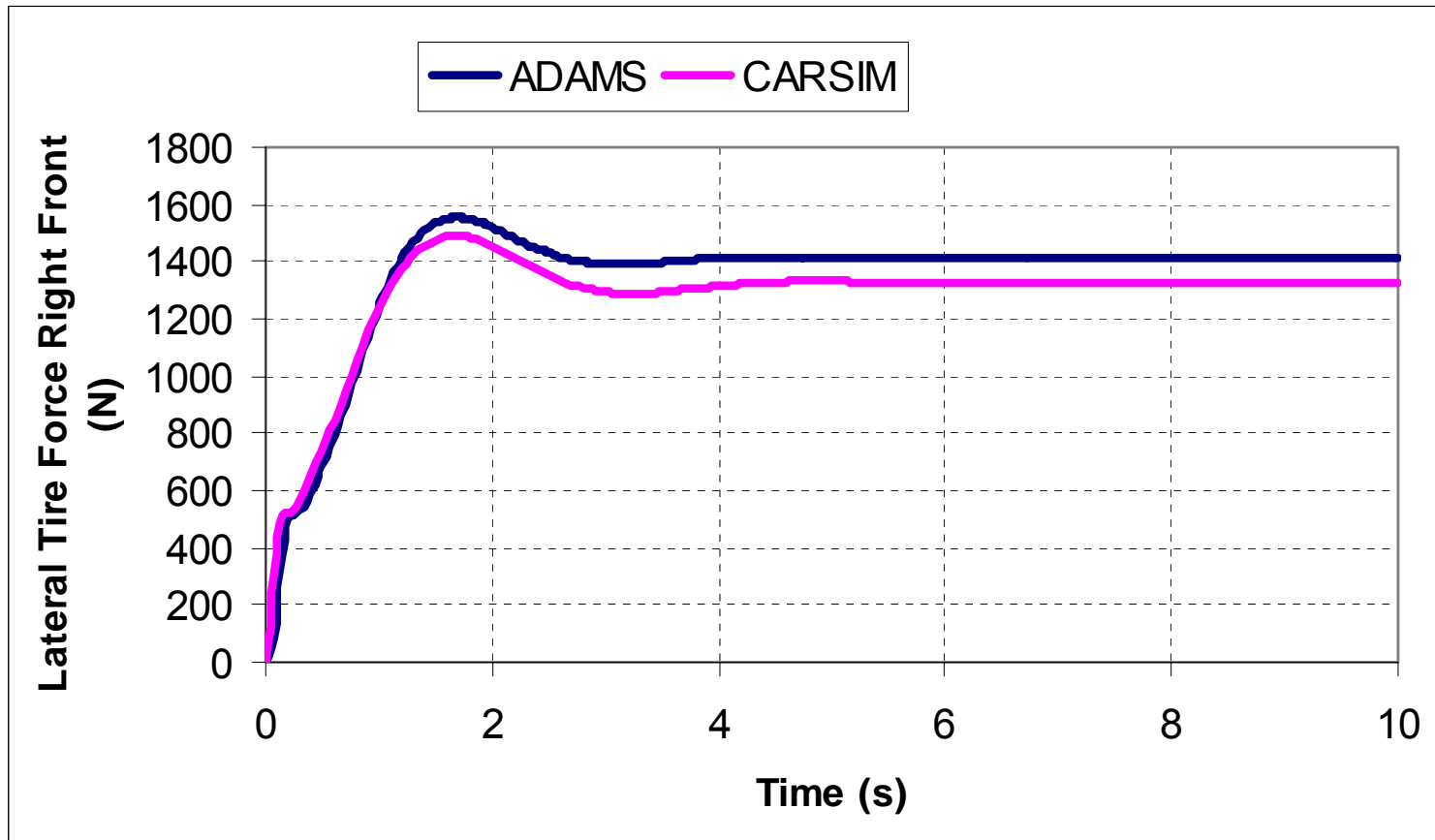


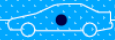
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Results – Lateral Tire Force

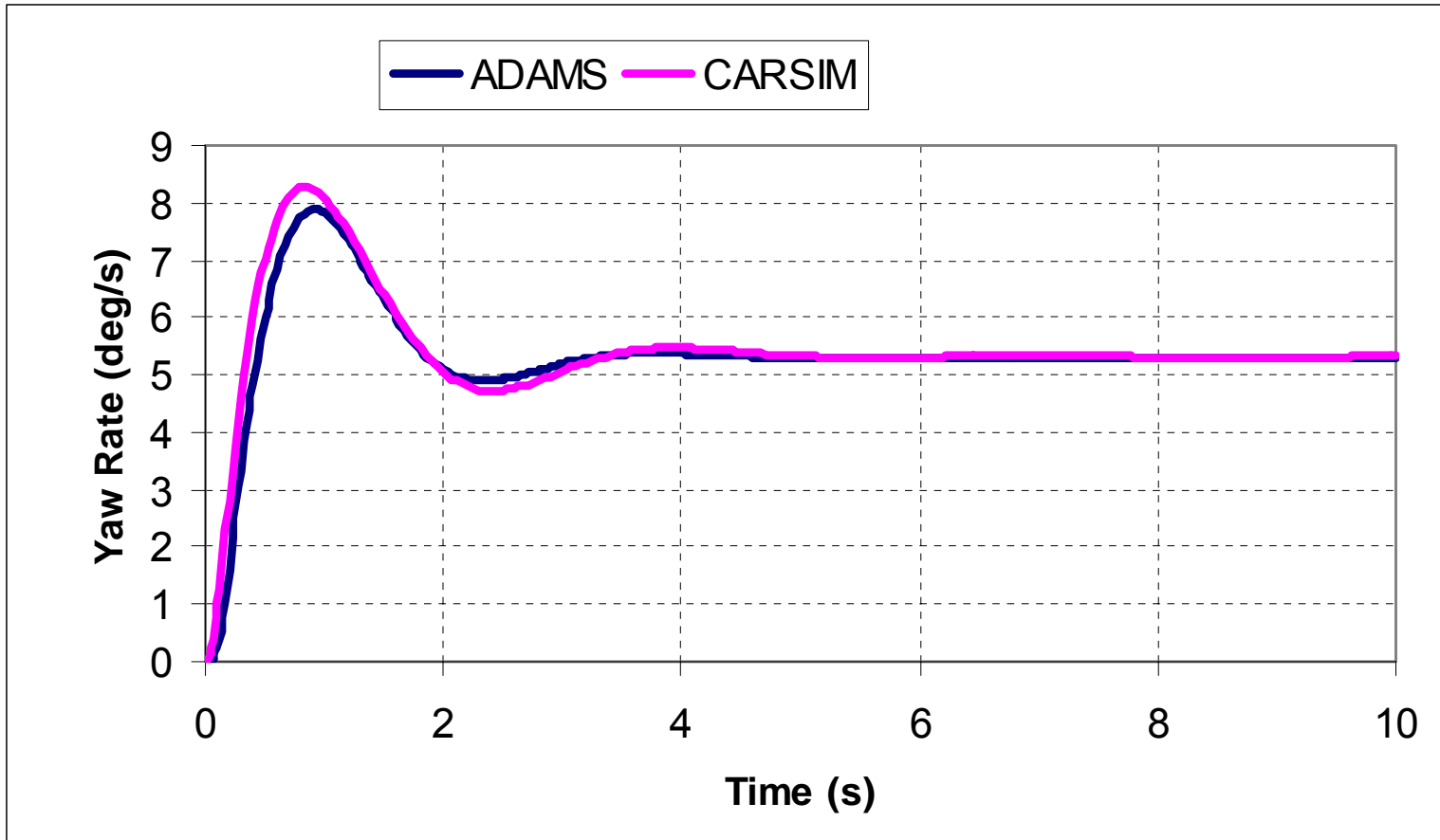
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Results – Yaw Rate

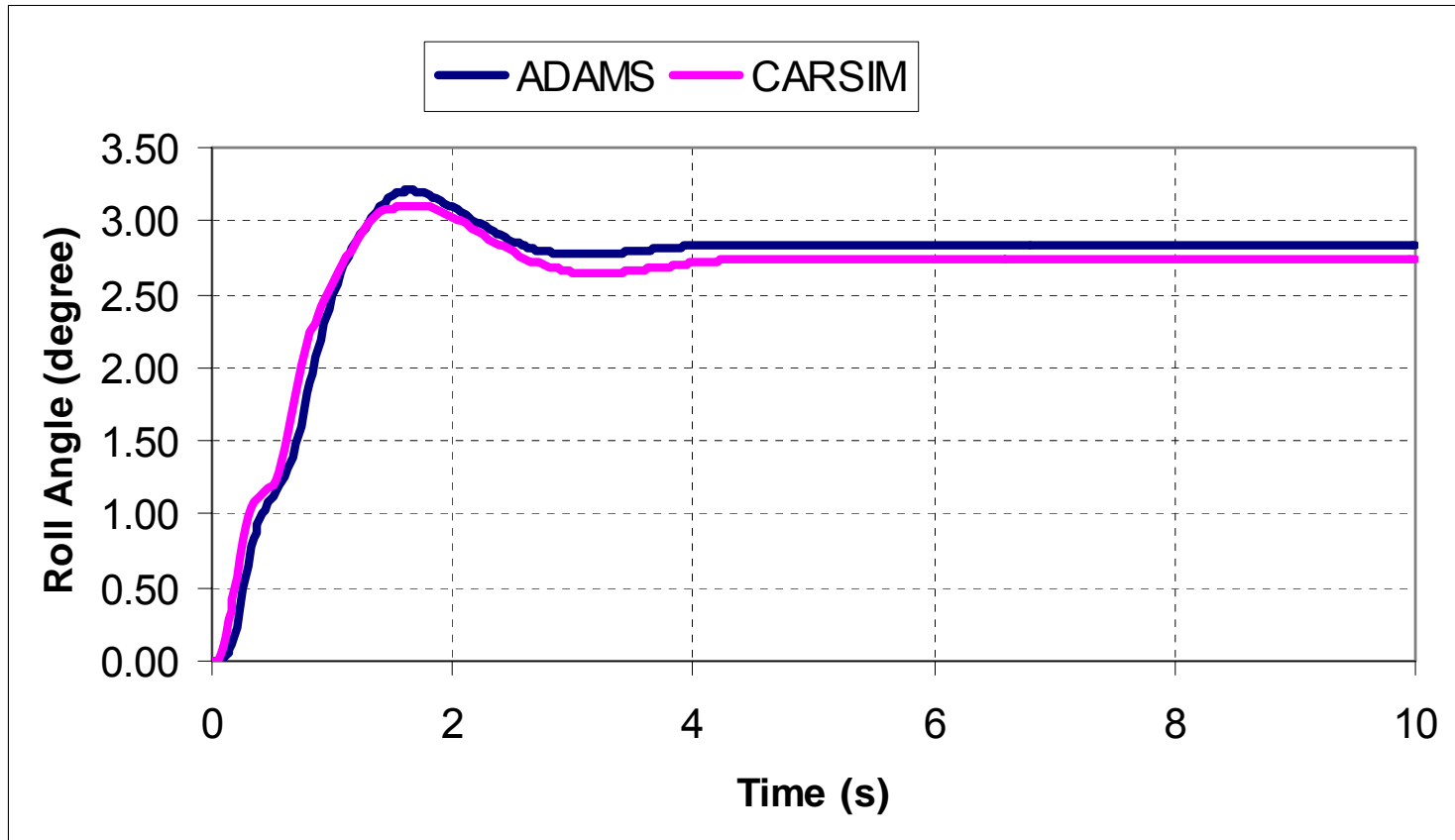
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Results – Roll Angle

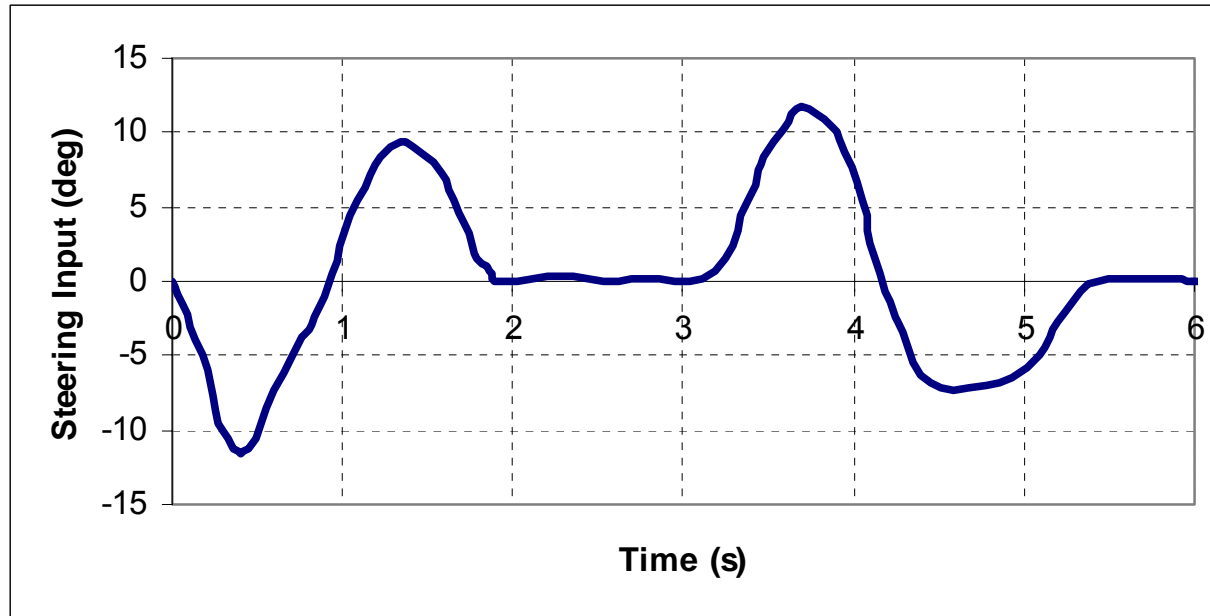
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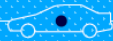
Double Lane Change: NADS vs MSC.ADAMS

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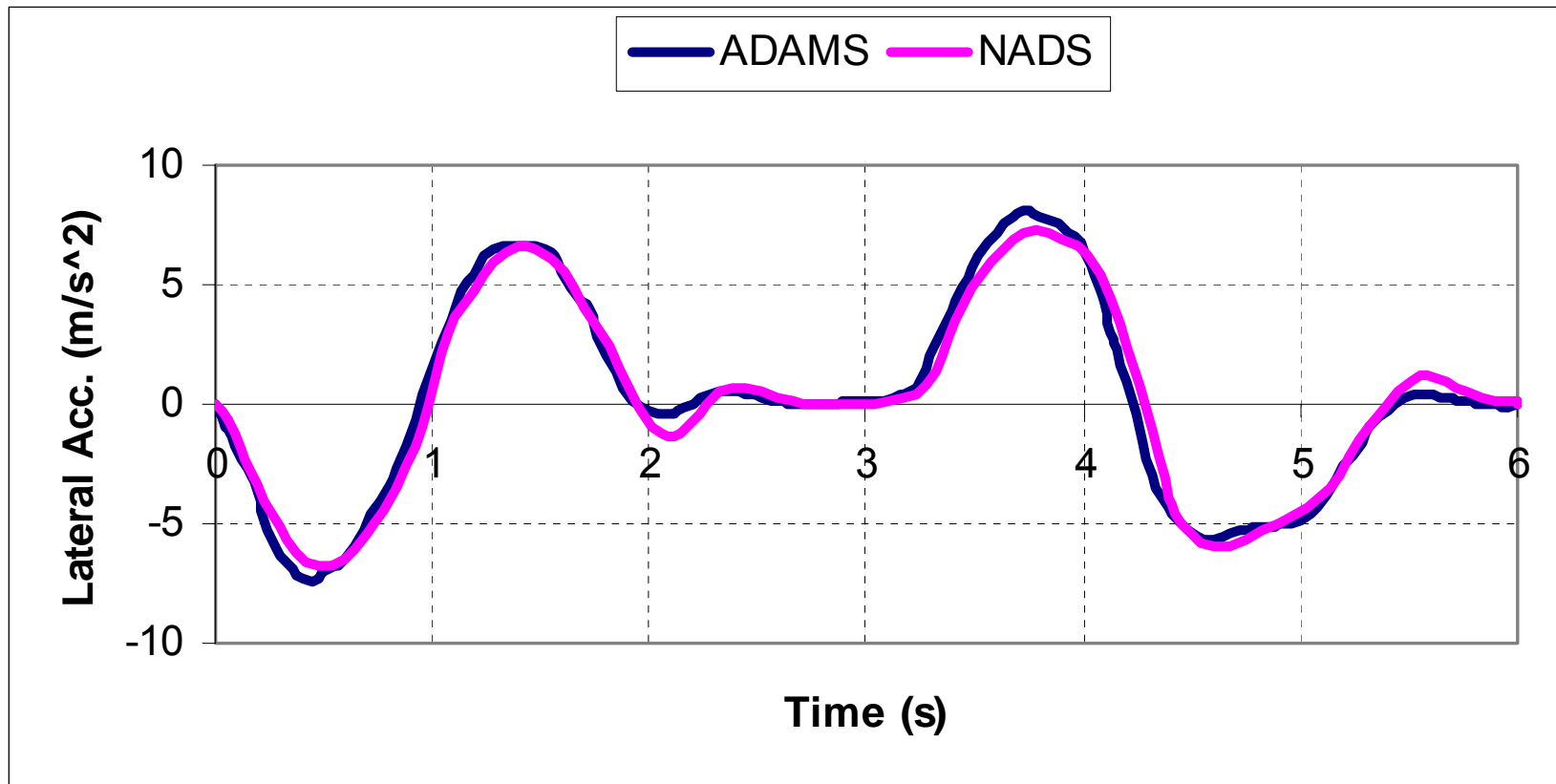
- Data from National Advanced Driving Simulator (NADS) for a 1998 Chevrolet Malibu.
- Vehicle speed corresponding to this maneuver is 26 mph.

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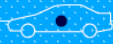


Results – Lateral Acceleration

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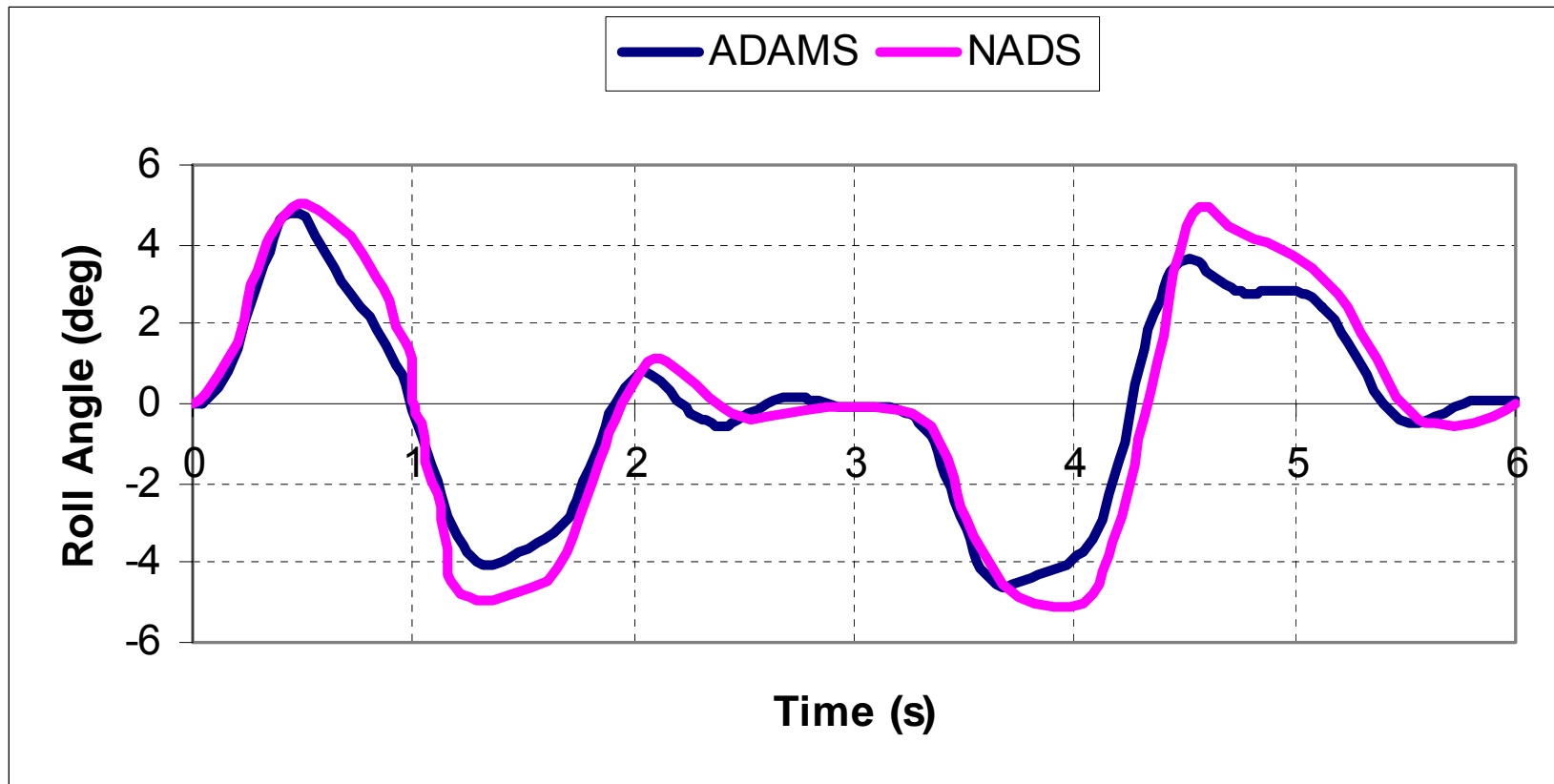


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Results – Roll Angle

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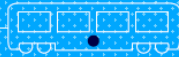
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Error Analysis

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| Error | Acc. Time (%) | Acc. Peak (%) | Roll Time (%) | Roll Peak (%) |
|-------------|---------------|---------------|---------------|---------------|
| First Peak | 6 | 7 | 6 | 4 |
| Second Peak | 1 | 1 | 5 | 19 |
| Third Peak | 2 | 11 | 3 | 9 |
| Fourth Peak | 1 | 5 | 2 | 26 |



Conclusions

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- A generic 3D vehicle dynamics model including a simple suspension system to study handling performance is developed.
- GUI offer
 - Flexibility
 - Quick Analysis of Vehicle Handling Performance
- Model show good correlation with
 - CarSIM Educational
 - National Advanced Driving Simulator (NADS)
- MSC.ADAMS Provides Great Capabilities for Virtual Prototyping