

SIMPACT User Meeting 2003



# DAIMLERCHRYSLER

## Commercial Vehicles Analysis

# Nonlinear Frequency Response: Application of a New SIMPACK Feature

06/05/03

Imre BOROS



## Frequency Response Methods

Workflow at SIMPACK

Graphical Output

1/4-Car Model

Non-linear Elements:

Bumper

Hydraulic Damper

Results 1/4-Car:

Degree of Non-linearity

Transient Step Input

Excitation Amplitude

Results Full Vehicle Model

chassis non-linearity

Mode shape at

Low Velocity

High Velocity

Results Full Vehicle Model

Excitation Amplitude

Outlook:

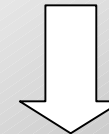
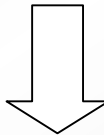
Tyre Model Extension

Frequency response analysis of non-linear systems



approximate non-linear into linear characteristics of the system

calculate response of non-linear system at harmonic excitation by time integration

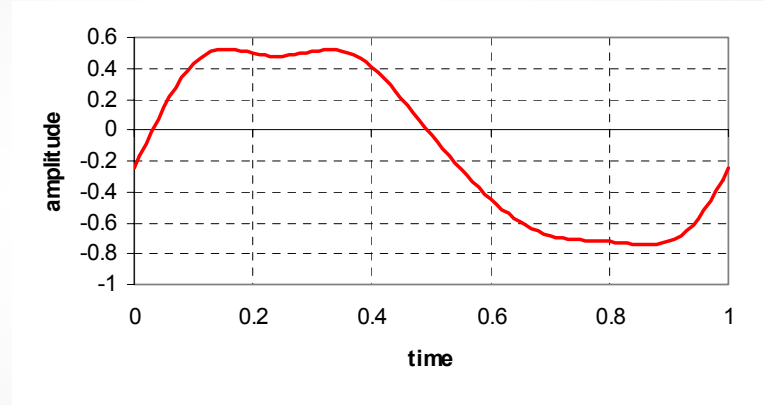
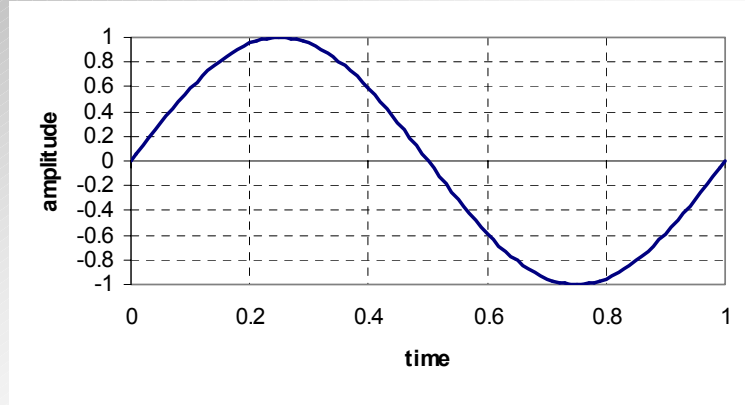
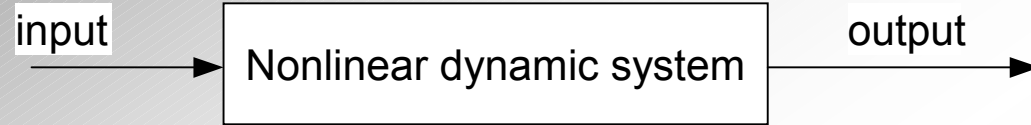


calculate frequency response

analyse the result by Fourier series decomposition

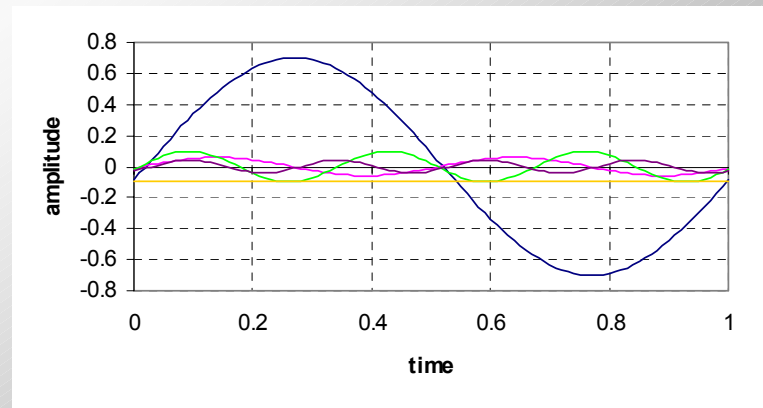
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$$u(t) = A \sin(\omega t)$$

$$y(t) = a_0 + \sum_{i=1}^{\infty} a_i \sin(i\omega t + \phi_i)$$



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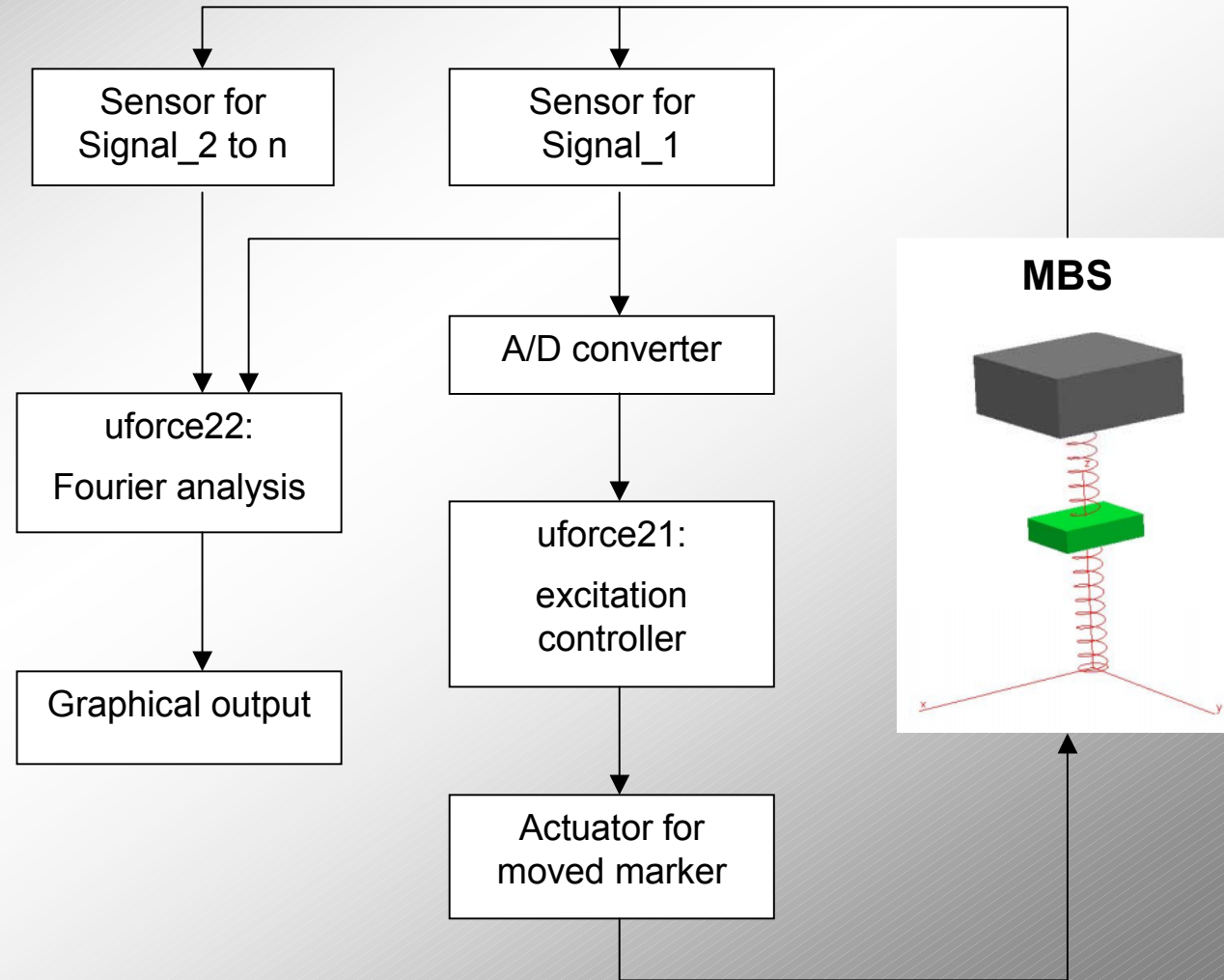
Results Full Vehicle Model

- Excitation Amplitude

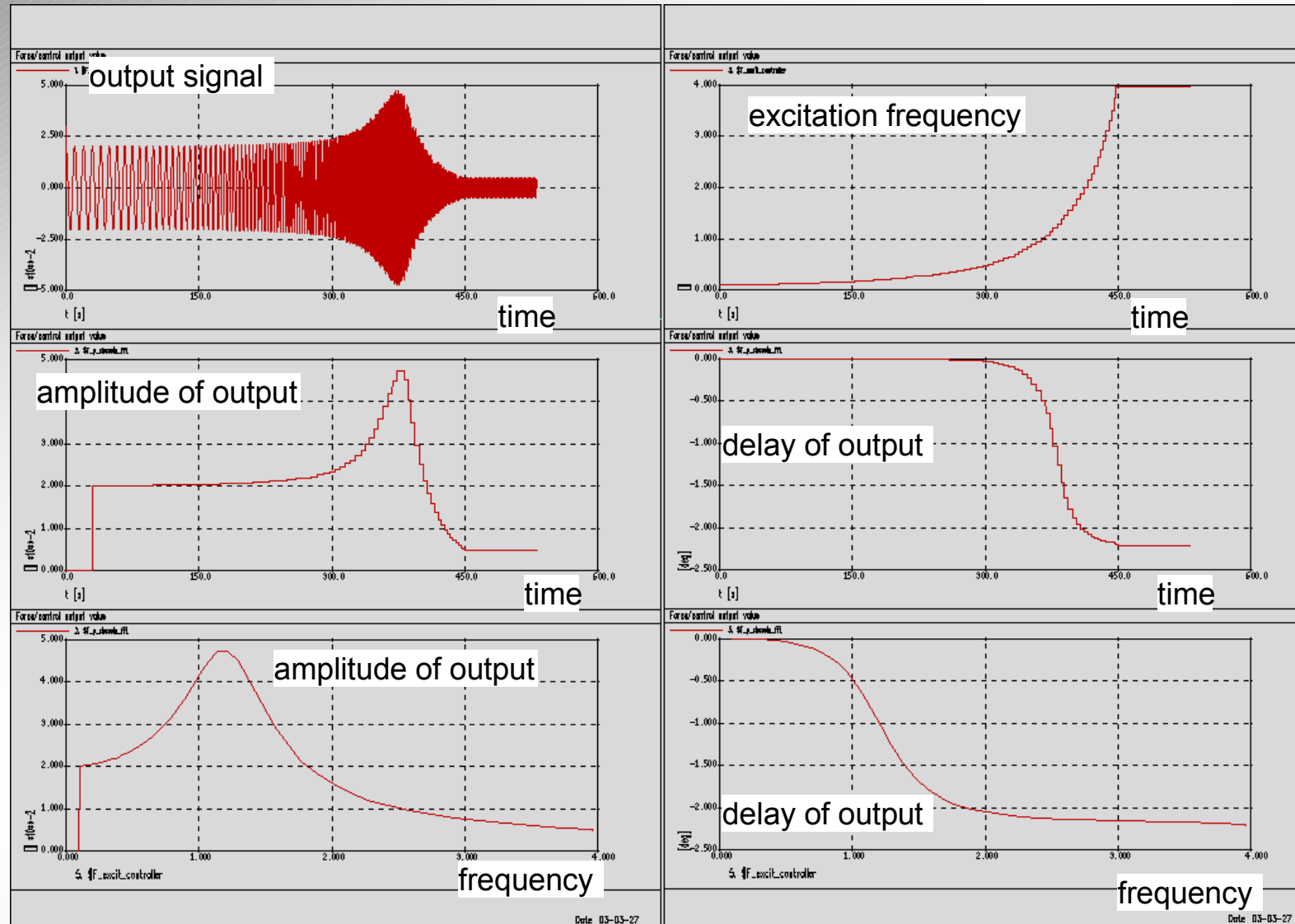
Outlook:

- Tyre Model Extension

Workflow at SIMPACK

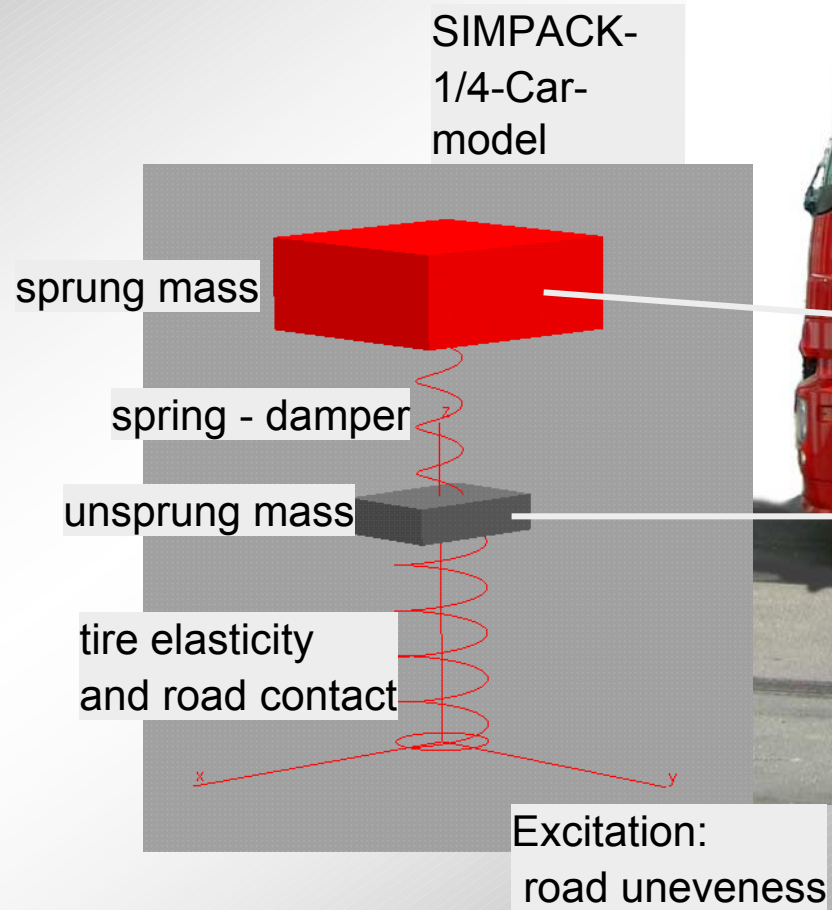


Frequency Response  
Methods  
Workflow at SIMPACK  
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Frequency Response  
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1/4-Car Model  
**Non-linear Elements:**

- Nonlinear chassis elements:**
- Bumper
  - Shock absorber

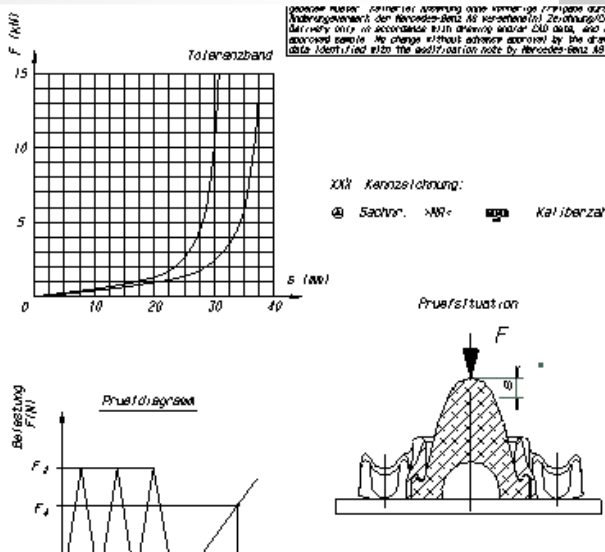
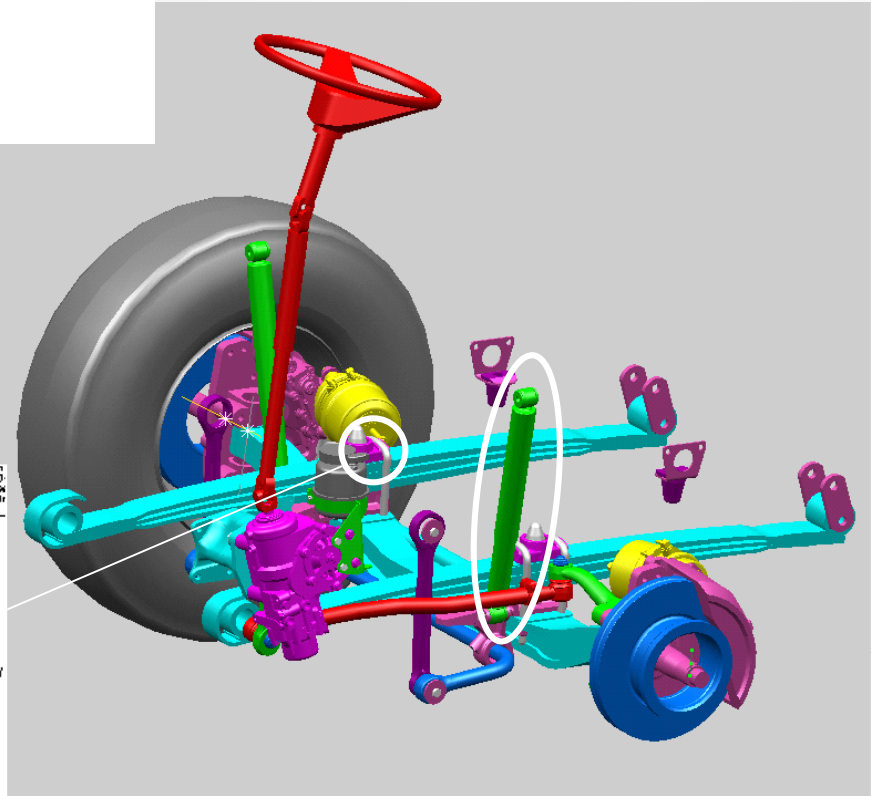
**Bumper**  
**Hydraulic Damper**

Results 1/4-Car:  
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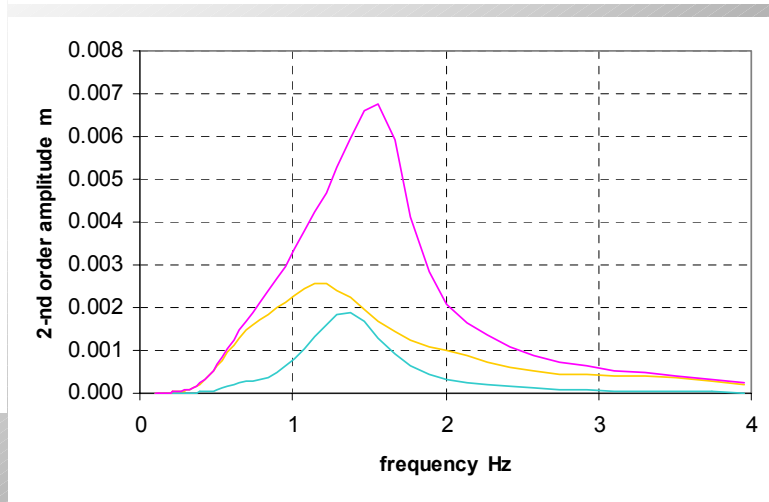
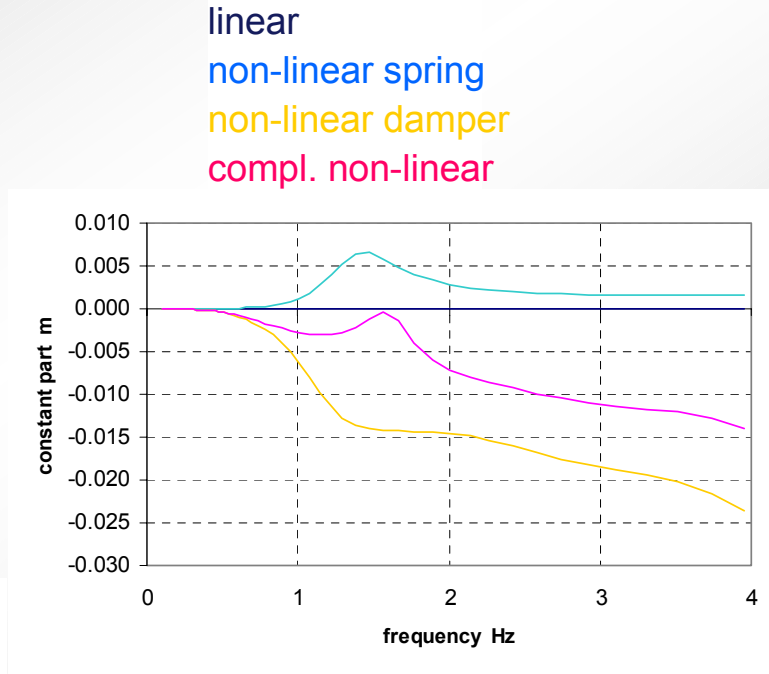
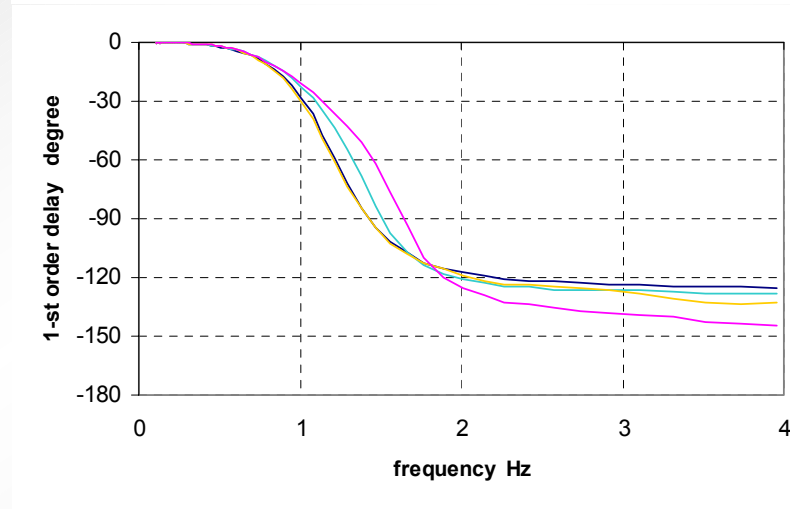
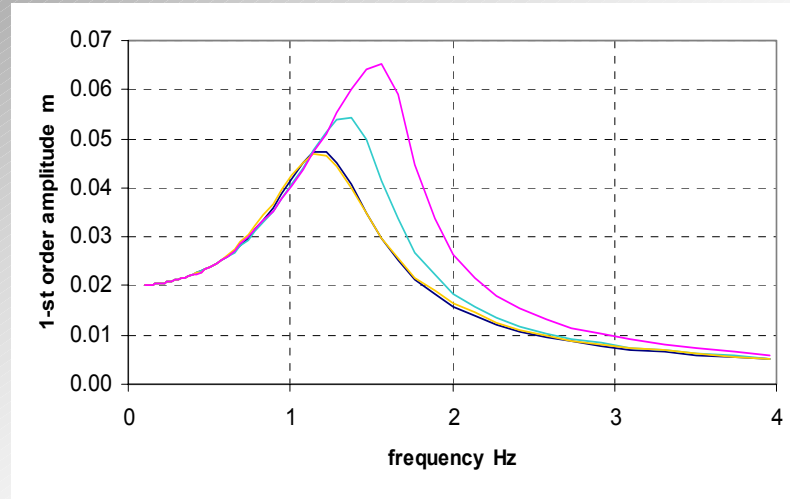
Tyre Model Extension





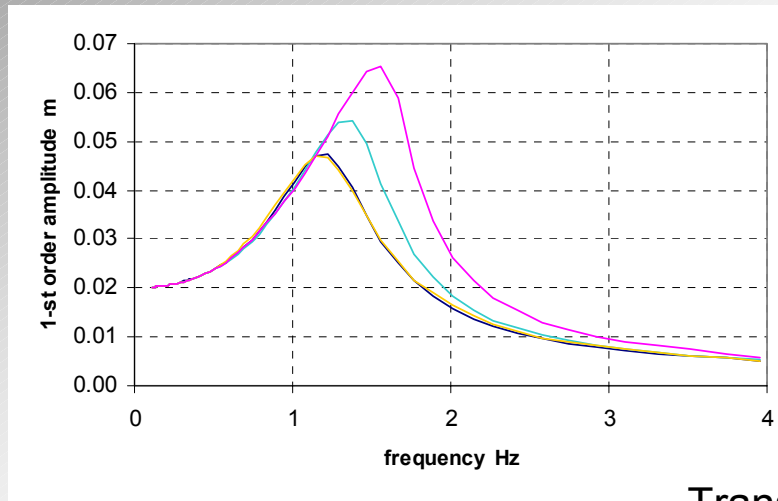


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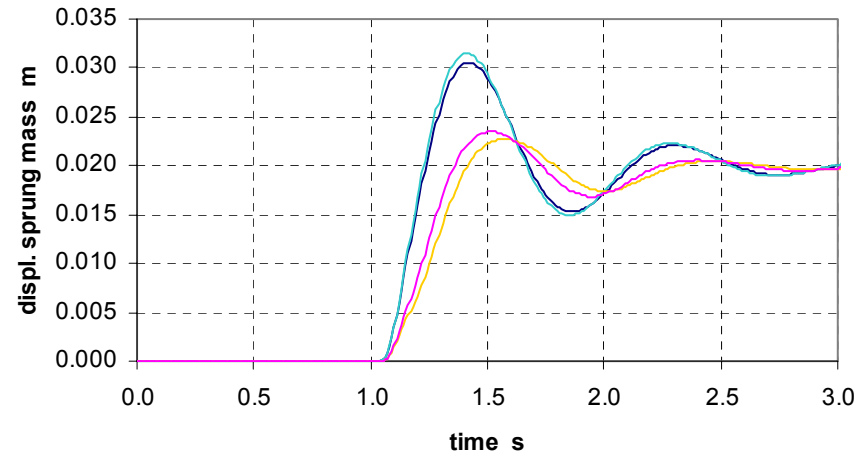


linear  
 non-linear spring  
 non-linear damper  
 compl. non-linear

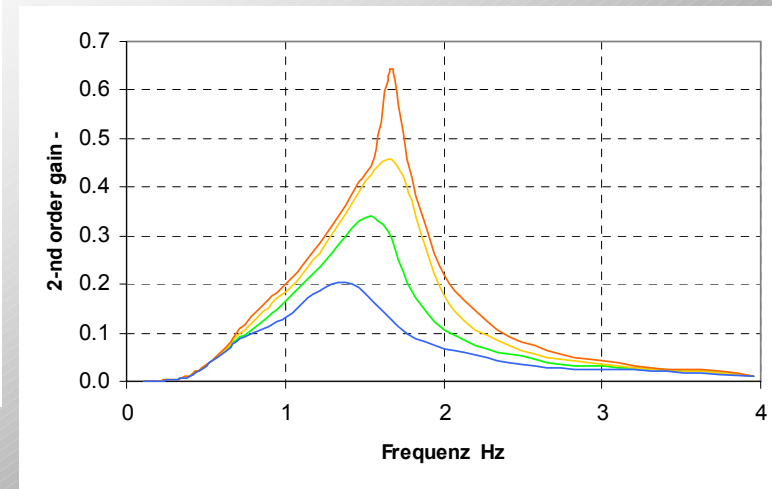
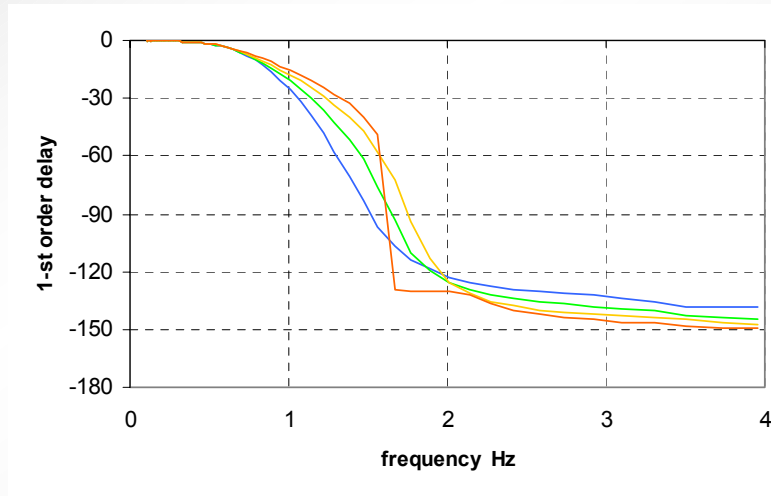
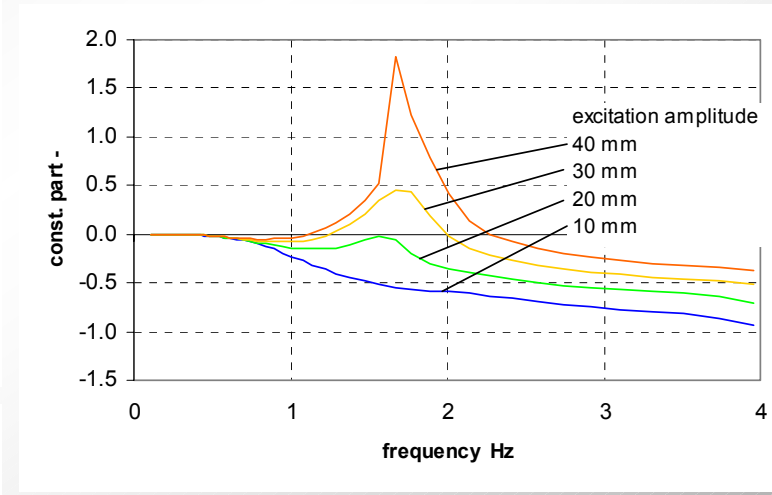
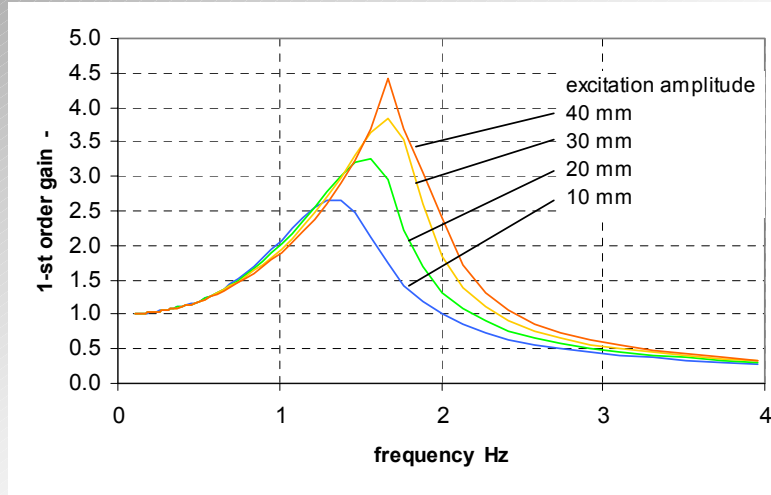
Results controversial,  
 additional results desired:

- power of excitation
- accuracy of first order approx.

### Transient step input

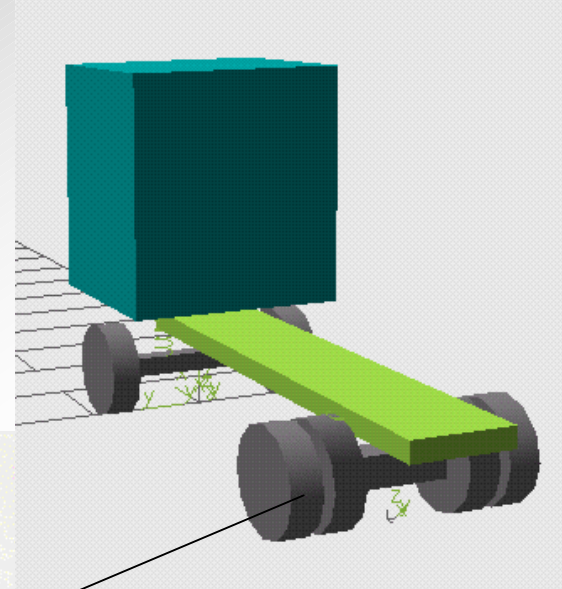


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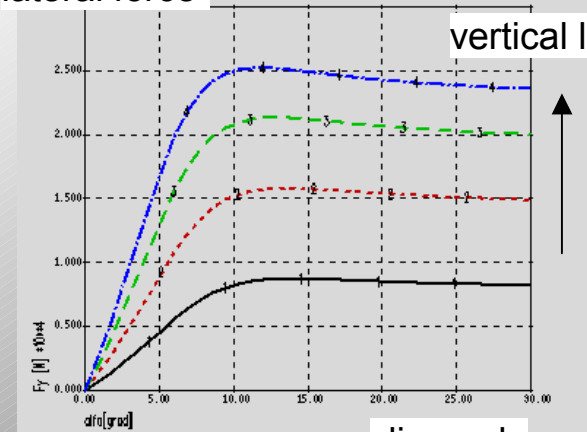
non-linear element: tyre



1 = 10000.0 [N]  
2 = 20000.0 [N]  
3 = 30000.0 [N]  
4 = 40000.0 [N]

lateral force

vertical load



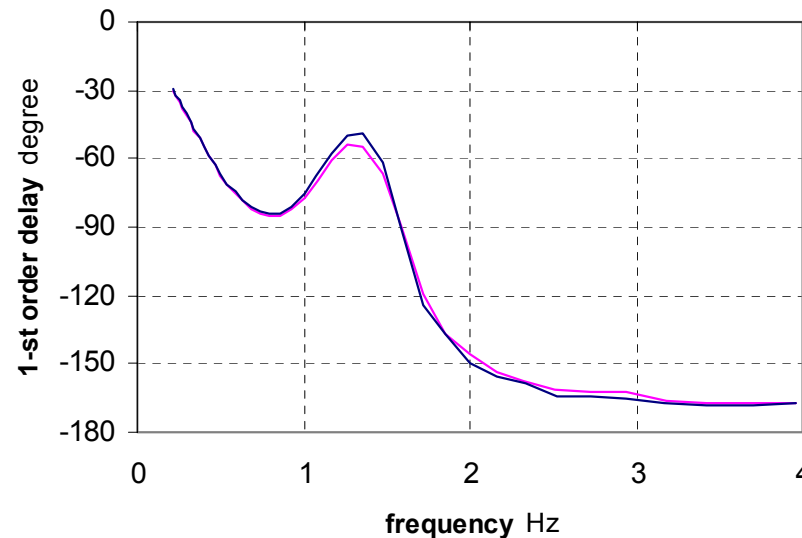
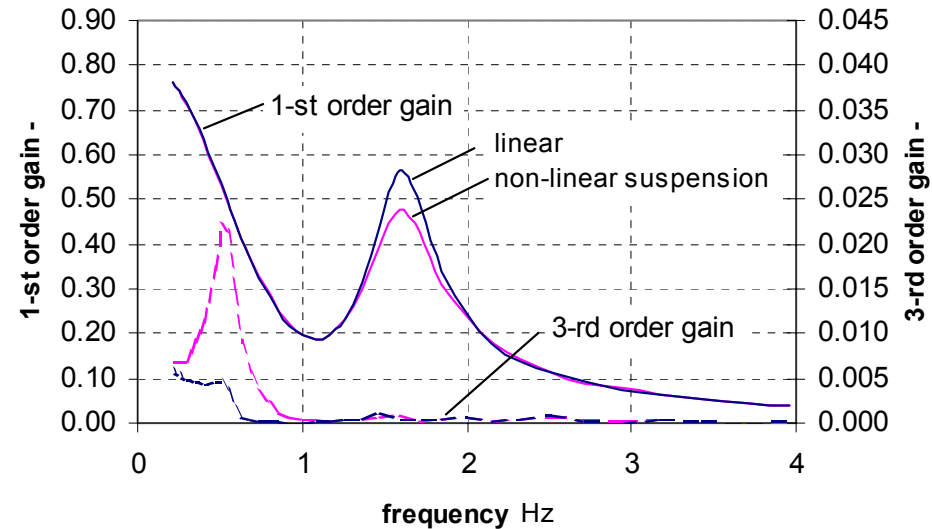
slip angle



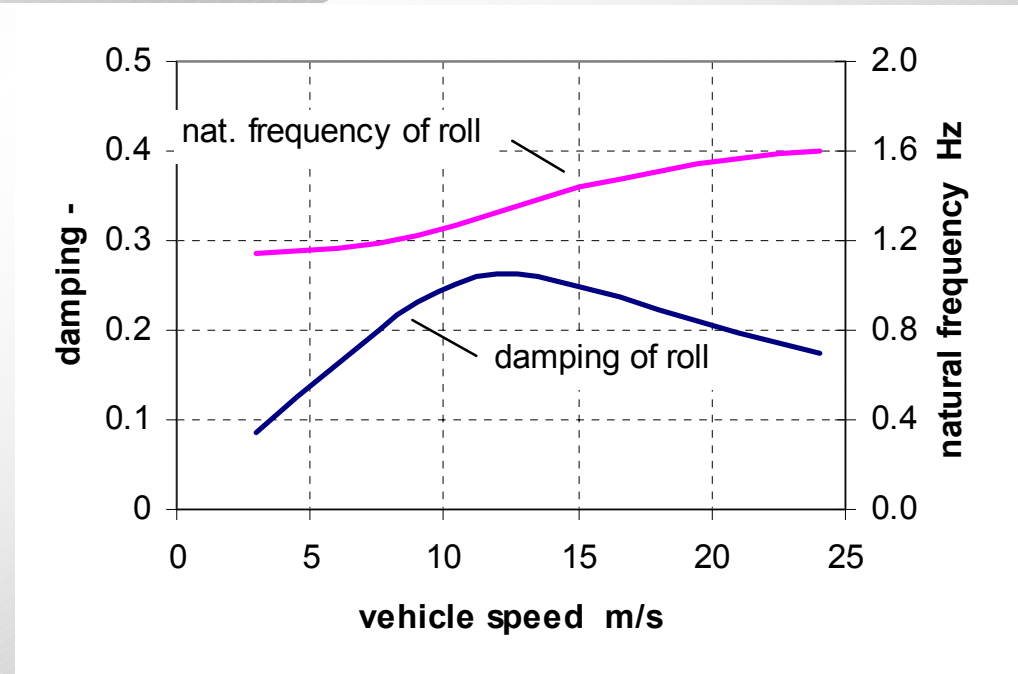
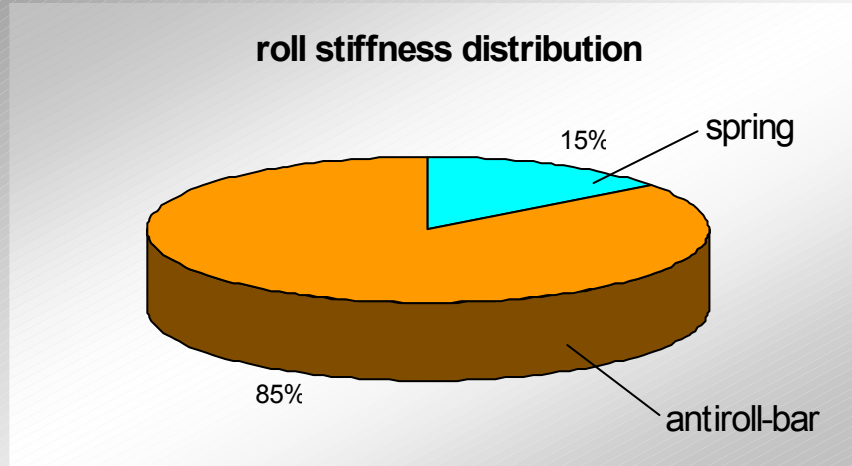


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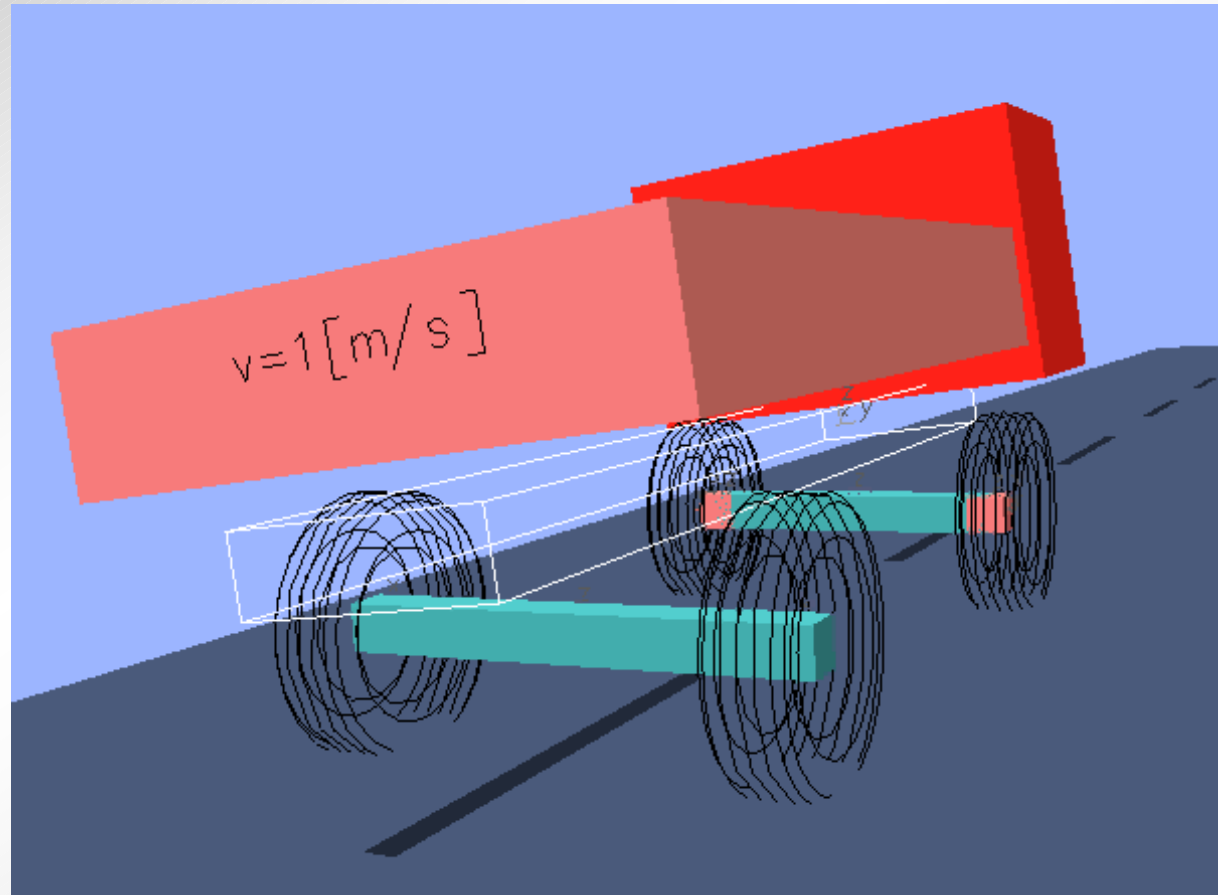
## Vehicle roll at steer angle excitation



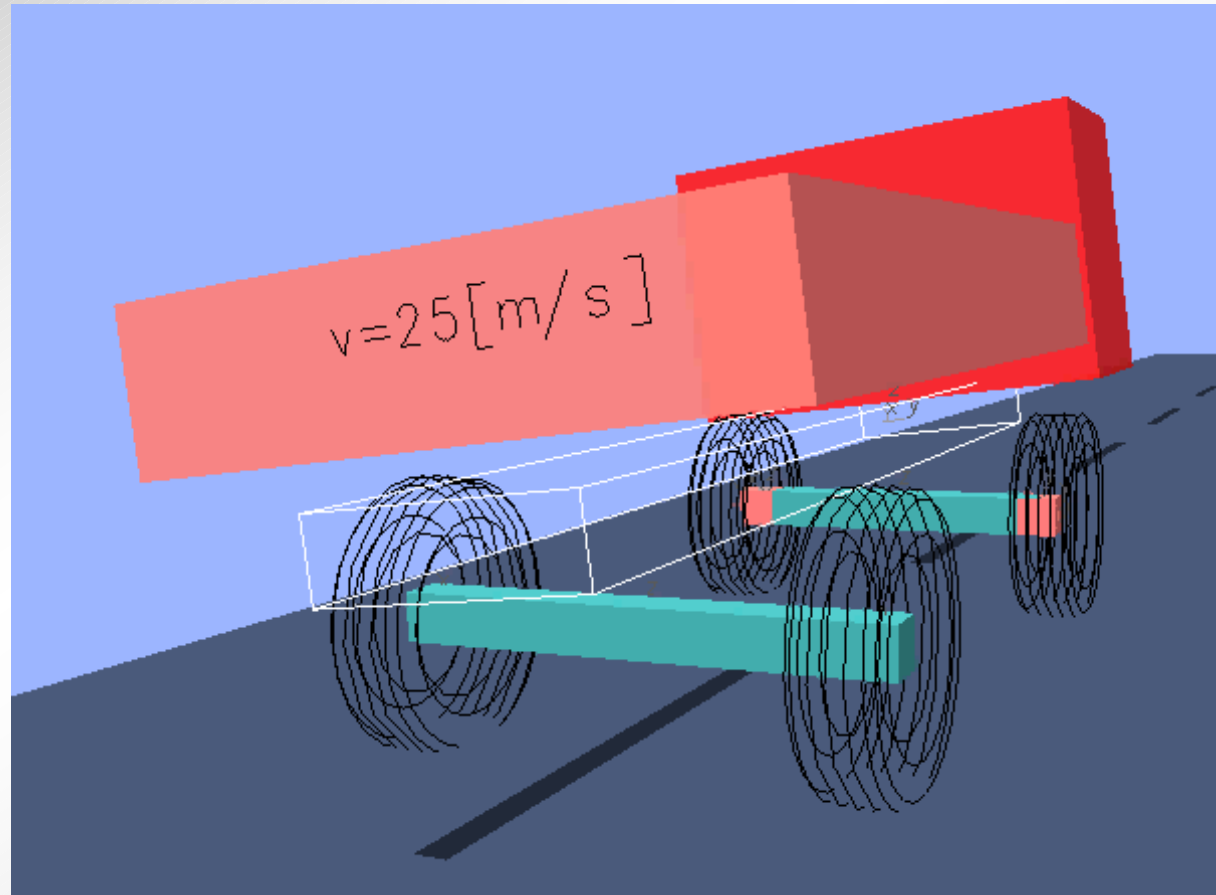
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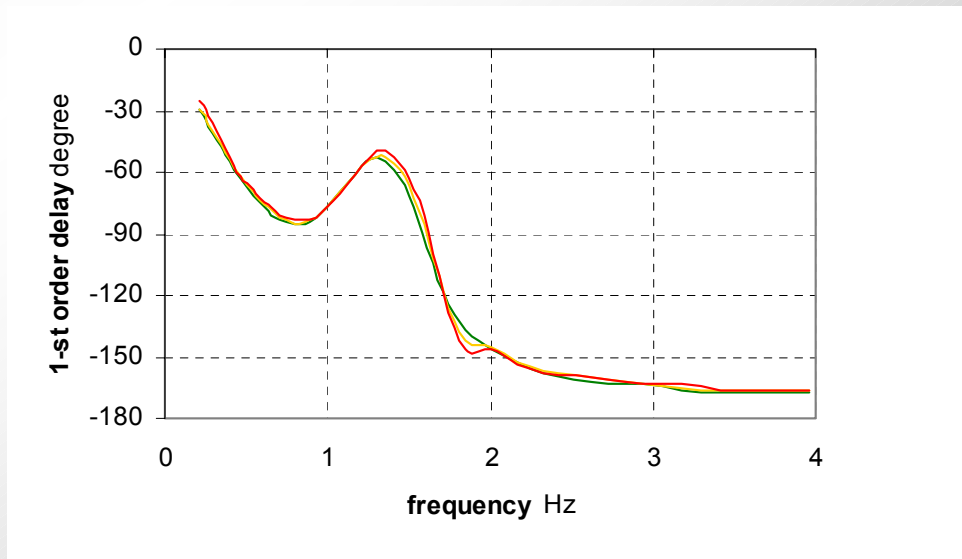
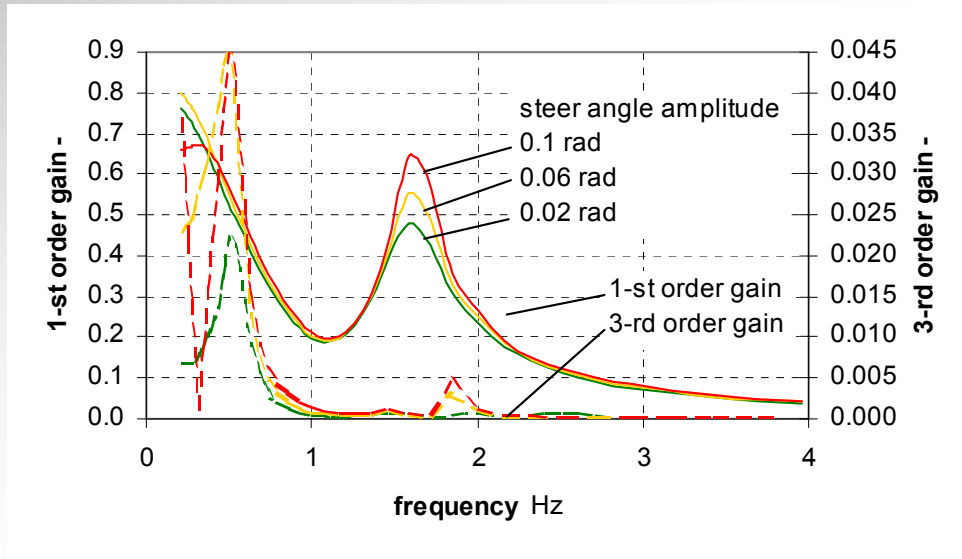


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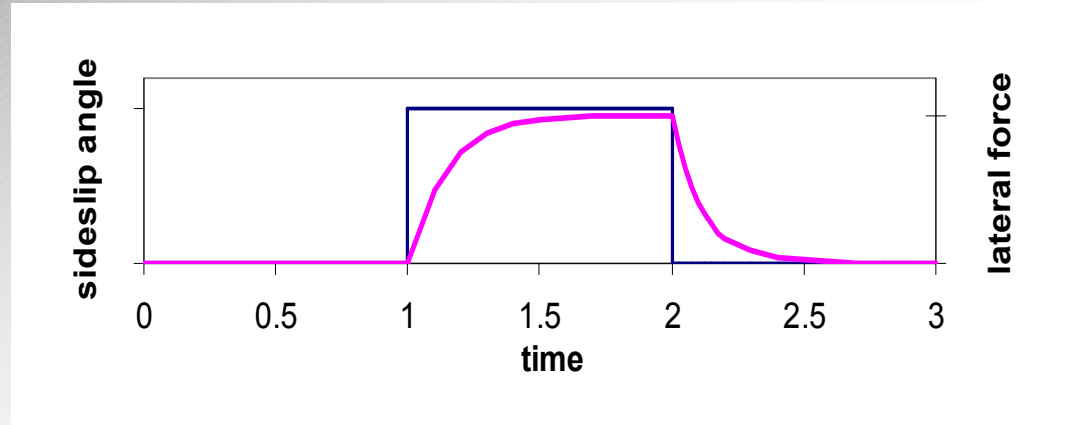
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## Time dependency of lateral force:

Dependent on side slip angle: linear



Dependent on vertical load: non-linear:  
delay for load and unload different

