Hand-in assignment: Module dynamics in Vehicle Motion & Control, TME102 7.5 ETCS Study period 4, 2023

Fredrik Bruzelius, email:fredrik.bruzelius@chalmers.se

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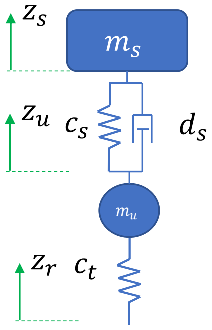
Abstract

This hand-in assignment is the examination of the first module on dynamics. Please hand in your solutions **before the 19th of April**. Please provide your solutions in CANVAS in pairs (two students). Remember that short and concise is beautiful, short answers will be favored. Simple calculation mistakes will be forgiven to a certain extent, as long as they dont lead to unreasonable results. The total sum of points on the assignment is 6, out of more than 2 is needed to pass (grade 3).

In this hand-in we will focus on the vertical dynamics of vehicle in the shape of a 1/4 car model. Variables and measures that you shall use is given below:



- The sprung mass $m_s = 1600kg$.
- The unsprung mass $m_u = 200kg$
- The suspension stiffness $c_s = 76 \cdot 10^3 N/m$.
- The suspension damping $d_s = 9 \cdot 10^3 Ns/m$
- The tire stiffness $c_t = 764 \cdot 10^3 N/m$
- We assume all component to act in a linear manner.

Linear systems

Assignment 1 (1p)
Formulate the model as a state space form. Then, use the numerical values as stated above to obtain a transfer function. Use the road profile position z_r as the input and the position of the sprung mass z_s as the output.

Assignment 2 (1p)
Can you describe the steady state (equilibrium) point in words? Is your model stable w.r.t. to this point? Is your system stable w.r.t to the input (road excitation), i.e bounded input gets bounded output? Can you tell if a particular choise of dapers and springs will make the system unstable?

Assignment 3 (1p)
Plot the bode diagram of the model. Describe what you get, e.g. is there some extra interesting frequencies, what do they mean? What happens at low and high frequencies?

Assignment 4 (1p)
What is the relative degree of this system? Is it possible to invert the system and make the sprung mass position the input and the road profile the output? Explain your answer

Nonlinear systems

Assignment 5 (2p)
In vehicle design it is most often desicrable to have a higher damping characteristics (up to 3 times for cars) for extension than for the compression. A model of damper force could be,

$$F_d = \begin{cases} 3/2d_s & (\dot{z}_s - \dot{z}_u) > 0 \\ d_s/2 & (\dot{z}_s - \dot{z}_u) \leq 0 \end{cases}$$

Lets say that we would like to use our linear theory to investigate freqency response of a suspension with a damper as described above. Explain how this could be done? Are there any challanges? Outline a way to tackle the problem. You dont *need* to make any numerical calculations or simulation, but show with expressions and argument how you would proceed.

Useful Matlab commands

If you use Matlab (or Octave), there are some useful commands that might support you in this handin:

tf() Create a transfer function object

ss() Create a state space object

bode() Plot a bode plot of a state space or transfer function

pole() return the poles

zero() return the zeros