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2023/2024
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Assignment 2: Simulink Modelling of Dynamic Systems

ME40064: System Modelling & Simulation

The overall aim of this assignment is to develop, verify, and use a model of a ½ car system, building on the ¼ model in the tutorials.

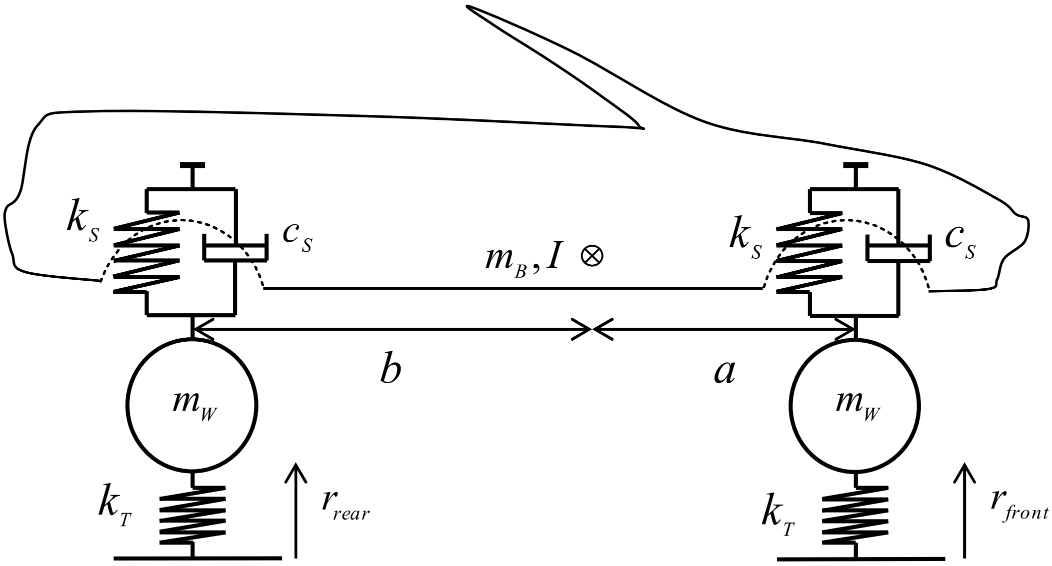

Figure 1: Representation of the 1/2 car model

Having completed Tutorial 9 you will have developed the suspension and wheel models. The main changes will be in the body model, which now represents ½ a car, and couples together the front and rear wheel assemblies. The equations of motion of the 1/2 car body are as follows:

$$m_B \ddot{s}_B = F_{front} + F_{rear} - m_B g$$
$$I\ddot{\theta} = aF_{front} - bF_{rear}$$

where s_B and $\boldsymbol{\theta}$ are vertical (positive up) and pitch (anti-clockwise) displacements about the centre of mass, and F_{front}, F_{rear} are the upward forces exerted by the suspension systems on the body, at the front and rear, respectively. The equations for the wheel and suspension models are as before.

The parameters for this model are given below:

Wheel: $m_W = 20$ *kg*, $k_T = 14 \times 10^4$ *N/m*

Suspension: $k_S = 2 \times 10^4$ *N/m*, $c_S = 600$ *Ns/m* (under contraction) & *1200 Ns/m* (under extension). Spring hardening parameters: $k_{Sstiff} = 20k_S$, $x_0 = 0.2$.

Body: $m_B = 700$ *kg*, $I = 650$ *kg/m*^{2}, $a = 1.35$*m*, $b = 1.5$*m*

Part 1: Model Construction & Verification

(a) Create an icon block for the 1/2 car body with suitable inputs (forces) and outputs (including vertical displacements/velocities at suspension points). Verify that your 1/2 car body model is correct and explain the reasoning behind your verification tests. **[15%]**

(b) Connect the suspension and wheel models to the 1/2 car body. Verify that the complete 1/2 car model is correct and explain the reasoning behind your verification tests. **[15%]**

Part 2: Investigation of Car Performance

(c) Simulate the vehicle's transient response over a sinusoidal road of wavelength 1 m and a range of amplitudes between 0.01 m and 0.1m. Choose a suitable range of speeds for your simulations and explain your results. **[20%]**

(d) Now use your model to investigate the effect of a speed bump on car performance. **[40%]**

i. Define one or more speed bump profiles and assess the effect of speedbump parameters on car behaviour and performance. Some typical idealised shapes include circular, sinusoidal, and trapezoidal. In practice, speed bumps are often a Watts profile or a Seminole profile. What implications do your results have for the design of a speed bump?
ii. Defining one or more key response characteristics, such as passenger (dis)comfort, investigate how you can optimise car parameters such as suspension stiffness & damping to improve performance over these speed bumps. Explain your findings.

Presentation Quality

Marks will also be given based on the quality of presentation of the work, including the following criteria **[10%]**:

- Clear graphical presentation of equations, text, diagrams, and plots
- Clear and organised Simulink diagrams
- Standard of written English

- Proper use of references, figure numbering & captions, and table headings
- Clear, logical layout of report

SUBMISSION GUIDELINES

The assignment should be written up as a concise report showing your Simulink models, model verification tests, simulation results, and conclusions. All the results should be presented clearly and properly explained. Simulink diagrams should be neatly organised and easy to read. You should demonstrate that your simulation results are converged. See Lecture 21 slides for further details on the model and what is required.

Submit your **report & the Simulink model files** using the online submission on the unit's Moodle page. As before this is an anonymous submission; therefore, **do not** include your name in the report, Simulink models, or filenames, but **do include your candidate number**. There is a **word limit of 2000 words.**

Your report will be marked against the following criteria:

- Correctness of model & numerical results
- Clarity of written explanations
- Clear presentation of report content, results plots, and Simulink diagrams
- Rigour of model verification and simulation convergence testing
- Thoroughness and real-world relevance of the performance investigations

Deadline: 4pm on Monday 15th January 2024.