ME40064: System Modelling & Simulation
ME50344: Engineering Systems Simulation
Lecture 21

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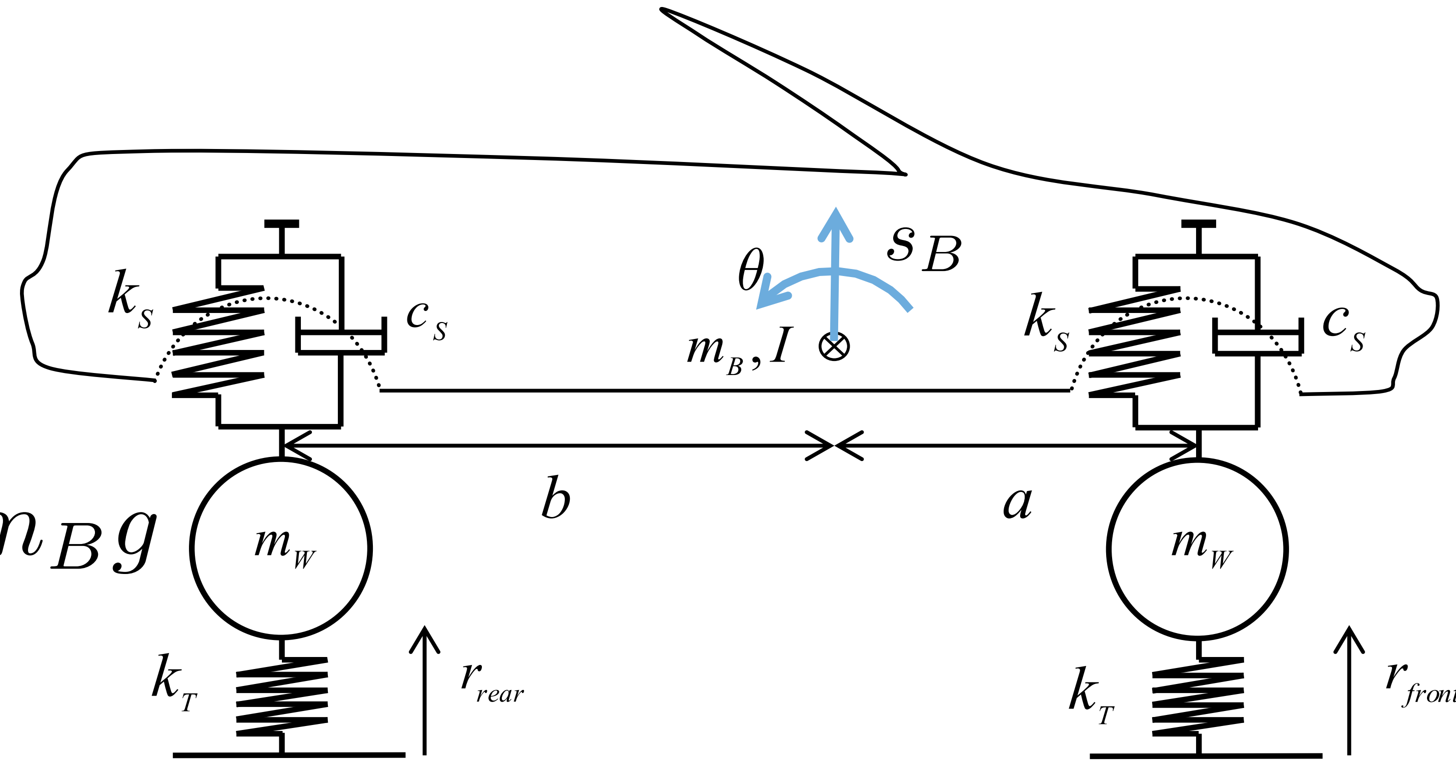
University of Bath, 2019-20

LECTURE 21
Coursework Assignment 3

- Introduce the coursework problem
- Introduce the relevant modelling concepts

1/2 CAR MODEL
The Governing Equations

Combine parts of 1/4 car model with new model for the body of a 1/2 car



Equations of Motion for 1/2 Car Body

Newton's 2nd Law - Linear Motion:

$$m_B \ddot{s}_B = F_{front} + F_{rear} - m_B g$$

Newton's 2nd Law - Rotational Motion:

$$I\ddot{\theta} = aF_{front} - bF_{rear}$$

Note: you may assume the small angle approximation $\sin\theta = \theta$ to relate θ, s_B and the displacements at the front & rear points of the car

MODEL VERIFICATION
Part 1 (A)

- Present the verification results for the ¼ car analysis of Tutorial 9, showing results first for each subsystem (body, suspension, wheel) and then the complete ¼ car model
- Include in your model the following nonlinear components:
  - spring hardening stiffness
  - shock absorber damping rate
  - tyre stiffness acting in compression only
- Worth 10%

MODEL VERIFICATION
Part 1 (A)

Verification Tests for the Non-linear Models

As the verification tests as written do not work for the non-linear versions, one approach could be the following sequence of steps:

1. Verify the whole system and subsystem blocks using the constant gains (i.e. linear) models first
2. Create the lookup table and verify it works correctly by sending in different inputs and checking the output is as expected
3. Finally, connect the lookup table into the relevant subsystem model and check that qualitatively the results have changed in the way you would expect

SUB-MODEL VERIFICATION
Part 1 (B)

- Create an icon block for the ½ car body with suitable inputs (forces) and outputs (including vertical displacements/velocities at suspension points). Verify that your ½ car body model is correct
- Explain the reasoning behind your verification tests, and demonstrate that the outputs are as expected for each input
- Worth 15%

CAR MODEL VERIFICATION
Part 1 (C)

- Connect the suspension and wheel models to the ½ car body. Verify that the complete ½ car model is correct, again explaining the reasoning behind your verification tests
- Adapt your ¼ car system model
- Worth 15%

PERFORMANCE INVESTIGATION
Part 2 (D)

- Simulate the vehicle's transient response over a sinusoidal road of wavelength *1m* and height amplitude, *h=0.01m*. Choose a suitable and meaningful range of speeds for your simulations.

$$r = h\sin(2\pi s)$$

$$s = vt$$

Vehicle speed

- Remember to apply a phase lag to the rear wheel
- Worth 20%

PERFORMANCE INVESTIGATION
Part 2 (E)

Choose a category of car e.g. sports car, rally car, family saloon etc.

- For a range of road inputs e.g. sinusoid, step, potholes, bumps, define desirable system response characteristics appropriate for your choice of car and how they are typically used
- For example, aspects of system response to investigate could be dynamic response of car body in both pitch and vertical displacement, as well as wheel displacement response
- Investigate the sensitivity of these responses to a range of design parameters, e.g. wheelbase, location of centre of mass, suspension stiffness & damping, tyre stiffness, and moment of inertia
- Use your model to investigate what the optimal parameter values/ ranges for your chosen type of car are, and why?

Worth 40% - note this is an open-ended task with a lot of freedom and scope

SUBMISSION
Report

- The assignment should be written up in a concise report showing your Simulink models, model verifications, simulation results, and conclusions
- You should demonstrate accuracy & convergence of your simulation results
- PDF and Word file formats are both acceptable.
- Word limit of 2000 words

SUBMISSION
Figures

- Regarding display of figures you could create them from the scope window: https://uk.mathworks.com/help/simulink/slref/scope.html
- Or export the data to the Matlab workspace and plot using Matlab plotting commands: https://uk.mathworks.com/help/simulink/ug/export-simulation-data-1.html .
- All axes should be labelled, with units, and figures should be numbered with descriptive captions.
- Figures for the verification tests can be placed in an Appendix, providing that the main report text explains the purpose and expected output of the tests, and the figures are properly referenced within your report.
- Simulink models should be labelled, with clear, aligned signal routes

SUBMISSION
Marking Criteria

Reports 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 investigation

SUBMISSION
Moodle Upload

- Upload both your report and your Simulink model files, including screenshots of your models in the report too
- Your reports are to be marked anonymously, therefore please do not include your name in your report, Simulink files, or the filenames. However, do include your candidate number in the first page of your report.
- Deadline: **4pm on Monday 13th January 2020**