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

Dr Andrew Cookson
University of Bath, October 2018

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

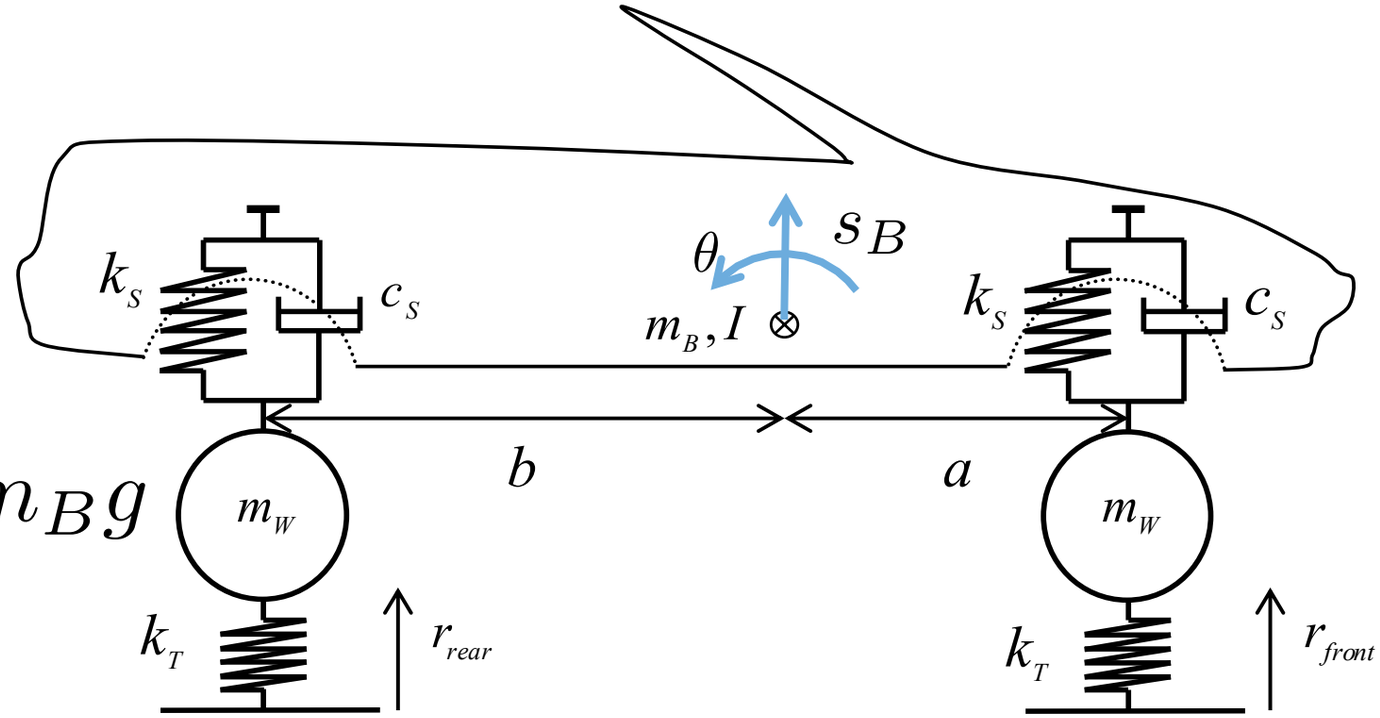
Equations of Motion for 1/2 Car Body

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
Task (a)

- Present the verification results for the ¼ car analysis of Tutorial 9, for each subsystem (body, suspension, wheel) and 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
Task (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. Replicate the constant gain using a lookup table and verify the test is still passed
3. Change the lookup table to represent the nonlinear model. Verify that the lookup table is working by isolating it and sending in different displacements (or other input as appropriate) and check the output. Finally, connect the lookup table into the relevant subsystem model.

SUB-MODEL VERIFICATION
Task (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
Task (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%

SIMULATING VEHICLE RESPONSE
Task (d)

- Simulate the vehicle's transient response over a sinusoidal road of wavelength *1m* and height amplitude, *h=0.01m*. Choose a suitable 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%

SIMULATING BRIDGE INPUT
Task (e)

- Simulate the ½ car going over a hump back bridge
- Hump back bridge input available on Moodle page
- Can you make the car fly?
- Check the tyre forces
- Worth 20%

By Arnautova Lina - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=20019389

EXTRA WORK
Task (f)

- Any other model attributes or simulations that you wish to present
- You have freedom here, for example:
  - Extra simulations or parameter space exploration
  - Additional model features
  - Response optimisation - choose a sensible requirement
- Worth 20%

SUBMISSION

- The assignment should be written up in a concise report showing your Simulink models, model verifications, simulation results, and conclusions
- One possible structure is a report about understanding and model a car's dynamic behaviour, explaining how you are increasing the complexity of the model (as directed and with any extra work you do) to gain additional information. At each step explain what that extra knowledge gained is, as well the explanations and evidence that each of your models are correct.

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

- 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.
- PDF and Word file formats are both acceptable.
- Word limit of 2000 words
- Deadline: 4pm on Monday 14th January 2019