Department of Mechanical Engineering
University of Bath

ME40064: Systems Modelling & Simulation
ME50344: Engineering Systems Simulation

Tutorial 9: ¼ Car Model & Verification in Simulink

Part A: ¼ Car Model

Following the block diagram in the slides for Lecture 17 create the ¼ car model, with the following parameter values m_1 =250kg, m_2 =20kg, k_s =2 x 10^4 N/m, c =1000 Ns/m, k =14 x 10^4 N/m.

a. Create your own icon blocks for the body, suspension and wheel models. Allow for spring hardening and different damper rates for contraction and extension in the suspension model. In the wheel model, if the tyre goes into tension, set the tyre force to be zero.
b. Form the 1/4 car model.
c. Apply a step input road profile.
d. Simulate the response of the 1/4 car. View body displacement, wheel displacement and tyre force.

Part B: Model Verification

Car body subsystem

a. Apply zero force as input with zero initial conditions. The expected output is that the body will fall under gravity with a negative parabolic trajectory for body displacement and a corresponding linearly decreasing negative velocity.

b. With zero initial conditions, apply a force input that is equal and opposite to the body weight. The expected output is that both displacement and velocity should be zero.

Suspension subsystem

a. Apply in turn unit values to each displacement and velocity input, checking that the output force values are as expected.

Wheel subsystem

a. With $k_T = 0$, similar tests as for the car body subsystem could be applied.

b. With $k_T \neq 0$, $F = 0$, $g = 0$, a step input in r from 0 to 1 should result in oscillations at an angular frequency $\sqrt{k_T / m_2}$, the mean value of s_2 being 1 and the mean value of $\dot{s}_2$ being 0.

Complete 1⁄4 car model

a. With $r = 0$, the wheel should settle to a displacement at which the tyre supports the whole vehicle weight: $(s_2 = -(m_1 + m_2)g/k_T)$. The suspension spring should support the car bodyweight: $(s_1 = -m_1 g/k_S + s_2)$.

b. Set k_S or c_S to be large values such that the body and wheel masses are effectively a single mass. Under a step input in r from 0 to 1, both masses should oscillate at the angular natural frequency $\sqrt{k_T/(m_1 + m_2)}$ with peak amplitude of 1.

c. Set k_T to be an abnormally high value, m_2 to be very small (non-zero). Under a step input in r from 0 to 1, the body mass should oscillate at the angular natural frequency $\sqrt{k_S/m_1}$ (if $c_S = 0$) with a peak amplitude of 1. If a suspension damper has a non-zero rate, the oscillations should decay. The wheel mass should follow closely the step input.